Electrochemical and Metallurgical Industry

VOL. III. NEW YORK, OCTOBER, 1905. NO. 10.

Electrochemical and Metallurgical Industry

Published on the first of each month by the
ELECTROCHEMICAL PUBLISHING COMPANY,
[*Incorporated.*]
114-118 LIBERTY STREET, NEW YORK.

J. W. RICHARDS, PH. D.....*President*
E. F. ROEBER, PH. D.....*Editor*

TELEPHONE CALL: 7607 CORTLANDT.

Subscription Price: $2 per year, postpaid to any part of the world. Single copies 25 cents.

ADVERTISING RATES GIVEN ON APPLICATION.

Copyrighted, 1905, by the Electrochemical Publishing Co.

Entered as Second-Class Matter, June, 1903, at the Post-Office at New York, N. Y., under the Act of Congress, March 3, 1879.

NEW YORK, OCTOBER, 1905.

CONTENTS.

EDITORIAL 363
Bethlehem Meeting American Electrochemical Society..... 363
The Huntington-Heberlein Process..... 363
The Chemistry of Electrochemistry..... 364
Recent Progress in Ore Dressing..... 365
NOTES ON ELECTROCHEMISTRY AND ELECTROMETALLURGY IN GREAT BRITAIN 366
CORRESPONDENCE
Lead Poisoning. By F. G. Hartman..... 368
Bethlehem Meeting of the American Electrochemical Society..... 369
W. S. Franklin and L. A. Freudenberger, on Colloids..... 369
Wilder D. Bancroft, on the Chemistry of Electrochemistry..... 370
Anson G. Betts, on Metal Deposition..... 371
Oliver P. Watts, on Aluminium as Reducing Agent..... 372
Gustave Gin, on Electric Steel Furnace..... 372
Anson G. Betts, on Refining Silver..... 373
F. D. Easterbrooks, on Parting of Bullion..... 373
Maximilian Toch, on Insulating Paints..... 375
Richard von Foregger, on Active Oxygen, Electrically and Chemically Produced 375
Chas. F. Burgess, on Arsenic in Pickling Solutions..... 377
G. F. Carrier, Jr., on Electrochemical Card Index..... 377
Oliver W. Brown and W. F. Oesterle, on Electric Zinc Smelting 377
Anson G. Betts, on Electrometallurgy of Antimony..... 379
F. F. Schuetz, on Pyrometer..... 379
R.Threl, on Specific Resistance of Electrolytes 381
C. F. Burgess, on Electrochemistry at St. Louis Exposition.... 381
W. S. Franklin and L. A. Freudenberger, on Reversible and Irreversible Polarization 381
Lawrence Addicks, on Ammeters for Electrolytic Work..... 381
E. F. Roeber, on Incandescent Lamps..... 382
Herman Schlundt and Richard B. Moore, on Radioactivity..... 382
G. A. Rousch, on Iodoform from Acetone..... 383
Gustave Gin, on Resistivity of Iron and Steel at High Temperatures 383
Action of Acids on Iron, and the Use of the Acid Pickle. By C. F. Burgess 384
Metallurgical Calculations, VIII. By J. W. Richards..... 387
ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS..... 391
RECENT METALLURGICAL PATENTS..... 393
SYNOPSIS OF PERIODICAL LITERATURE..... 394
BOOK REVIEWS
Transactions of the American Electrochemical Society 400
Hot-Blast Smelting 400
Metallurgy at the Lewis and Clark Exposition..... 402
News and Notes..... 403
Personal 405
DIGEST OF UNITED STATES PATENTS. Prior to July, 1902..... 406

Bethlehem Meeting of the American Electrochemical Society.

That electrochemists are not yet masters of the elements was proven by the inclement weather during the three days of the Bethlehem meeting of the American Electrochemical Society. But it is characteristic of the spirit of the members that the weather could not detract in any way from the good feeling which reigned supreme. As a matter of fact, the meeting was very much enjoyed and will long be remembered, thanks to the excellent arrangements made by the local committee. A full account of the proceedings and papers is given elsewhere in this issue, so that it may suffice here to point to the very broad range of subjects treated in the papers presented. The programme was broad enough to satisfy any taste; and this is necessary for the success of the Society. Electrochemical science and engineering is a special field, but one which is bound to make itself felt in a great many different industries and professions. The great interest with which electric furnace methods are now considered in the iron and steel industry was indicated by a long and animated discussion on the subject in connection with a paper of Mr. Gin. Otherwise, there was not very much discussion. Several decisions as to some special points of the future policy of the Society call for comment. There will be only one general meeting a year in future. This will undoubtedly lead to concentration and better attendance. However, arrangements may be made to hold a second meeting in conjunction with one of the other national engineering societies, as the American Institute of Mining Engineers, the American Chemical Society and the American Institute of Electrical Engineers. If carefully handled, such joint meetings must lead to an expansion of the interests of electrochemistry. Finally, the Society will encourage—and to some extent support—research work. Here is a most promising field, and any member of the Society can do useful work in this respect. A circular letter is to be sent out to all members asking for suggestions as to such research work as is considered of special importance. Even if only a small part of this work can be carried out with the support of the Society, yet a list of such suggestions should prove exceedingly useful, if the members respond to the request in the right way and in the professional spirit which has been from the beginning such a distinguishing feature of the Society.

The Huntington-Heberlein Process.

A chain is no stronger than its weakest link. A fleet is no faster than its slowest ship. A scientific investigation is no more accurate than its weakest determination. And, as in all these three examples, the metallurgy of a metal is no stronger than its weakest sub-process. In lead smelting there has been great recent progress in the mechanical charging of the blast

furnace, the mechanical handling of slag and matte, in the chemistry of slags, in the knowledge of the proper reduction of iron, and the elimination of this reduced iron by its reaction with sulphide or oxide of lead to form ferrous sub-sulphide or ferrous silicate respectively. Large advance steps have also been made in concentrating lead ores and in the mechanical and chemical sides of refining the base bullion. In the department of roasting lead sulphide ores, the attempts for improvement have met with but little success in this country until the present year. In fact, the Murray plant of the American Smelting & Refining Co., which was built recently by the combined experience of the best metallurgists of the trust, was equipped largely with the standard old-fashioned hand-rabbled reverberatory furnaces. Rotary roasters, such as the Brückner, stand idle at Pueblo, while the old types of hand roaster, which do not "snowball" the ore or cause excessive flue dust losses, are operated at a labor charge of $2.00 per ton. Furnaces, as the Ropp, Brown and McDougall, used with such success in roasting gold, zinc and copper ores, at a cost for labor and repairs of often as low as 25 cents per ton, are not capable of use on lead ores, because of the tendency of lead ores to form accretions on the hearth.

Accordingly, it is seen that in the lead business there was a great chance for improvement for a process founded on correct chemical facts and carried out on correct engineering lines. Such a process must succeed if it dispenses with that uncertain and unsatisfactory factor, the hand-rabbled roasting furnace. The Huntington-Heberlein process which fills this catagory has been developed in Europe and Australia in the past ten years, and is about to be exploited with modifications and improvements by the American Smelting & Refining Co., the purchaser of the rights for the United States and Mexico. This process combines into a homogeneous whole two facts long known to well-informed metallurgists. One of these is that the number of pounds of ore roasted per square foot of hearth area could be tremendously increased if it was possible to pass a current of air through the ore by means of porous or perforated hearth. The other is the fact that lime has a great affinity for sulphur, and will take unto itself sulphur on the slightest provocation. This is the case in the basic open-hearth furnace which uses a basic slag to eliminate the sulphur of the pig iron, and it is also applied in the iron-blast furnace by working the slag as basic as possible. Dr. Héroult uses in his electric furnace, with a very high temperature, a slag so basic as to be infusible in the lower temperature of the open-hearth furnace, and he can thereby easily "wash" all the sulphur from his metal. In the "Tarnowitz" process, working on lead ores, recourse has been long made to the desulphurizing properties of dolomite. And at the last meeting of the American Electrochemical Society, Brown and Oesterle corroborated the experiments of both Percy and Prost as to the extent of lime in desulphurizing zinc ores. Their paper will be found on another page of this issue.

In the Huntington-Heberlein process green or partially roasted lead ores are mixed with limestone and charged into a conical cast-iron converter, which has a perforated false bottom, air is blown gently through the ores, the temperature at first being held at 700° C., and then reduced to 500° C. At the end of this operation the mass is partially sintered, the sulphur being reduced to a low percentage. The converter is then tipped, the roasted product dumped, allowed to cool, broken up and charged into the lead furnace. The process has many advantages. The fuel cost and labor charge are both insignificant. The product is fitted by its physical characteristics for rapid smelting in the shaft furnace. The flue losses are extremely low, because the process is operated at such a low heat. A further advantage is the fact that the waste gases are high enough in sulphur dioxide to be used in the chamber sulphuric acid process. There are many successful imitations of this process; among which might be mentioned the Savelsberg and the Carmichael-Bradford. But all processes depend on the lime-sulphur reaction and on the ability of limestone to keep the charge free and open for the uniform flow of air. The chemical theory of any of these processes is not too well known, but the experimental facts are certainties, and after all experimenting is the basis of all our metallurgical knowledge. We are glad to chronicle this advance in lead smelting, for it shows a certain brotherhood in the metallurgy of metals, and beside, is a step in advance in the art of making metals from ores.

The Chemistry of Electrochemistry.

Dr. Wilder D. Bancroft's experimental lecture at the Bethlehem meeting of the American Electrochemical Society emphasized a point of view which has been generally neglected in the development of electrochemistry. The specific action of the electric current in electrolysis is considered here to be nothing but the transport and discharge of the ions. What then happens is looked upon as a problem of pure chemistry. By purely chemical experiments Dr. Bancroft endeavors to show which one of the various reactions that would be *a priori* possible, will actually take place. A weak point in this procedure would apparently be the difficulty to decide what the ions in a certain solution are. Dr. Bancroft says that this should be determined by some such method as Hittorf's, but it becomes daily more evident that such a method is not sufficient for the purpose. For instance, in an aqueous solution it is impossible to decide by measurements of the concentration changes alone whether there are complex ions (combinations of the simple ions with the molecules of the solvent) or not. However, for the purpose of Dr. Bancroft this is really a small matter. Take as example the development of the theory of the lead accumulator. Plante and many after him thought that the action during discharge was decomposition of water with a resulting change from lead peroxide to lead oxide on one side, and from spongy lead to lead oxide on the other side. Now, if they had looked on the problem as a chemical one, as Dr. Bancroft urges, the experiment would have suggested itself to make chemically lead oxide plates and place them in sulphuric acid. Then it would have at once been evident that something happens, that there is no chemical equilibrium. As a matter of fact, it was through Gladstone and Tribe's chemical researches that the sulphate theory of the accumulator was established. What shall be assumed as the hypothetical "primary" reaction in a certain case will depend on the hypothetical assumption of the nature of the ions; but whatever this assumption may be, chemical research will show what,

under this condition, the subsequent reaction must be. From the point of view of Dr. Bancroft it will always be possible to determine the whole action, and this is the main point.

Against this viewpoint of Dr. Bancroft, Mr. C. J. Reed emphasized, in a communicated discussion, the thermochemical point of view, as pronounced in Berthelot's principe du travail maximum. That process will take place which has the greatest heat of reaction; and since, according to Thomson's rule, heat of reaction is proportional to e. m. f., the determination of the e. m. f's corresponding to the different possible reactions from thermochemical data will show what reaction will really take place. If we only modify this view by substituting free energy of reaction for heat of reaction and Helmholtz' formula for Thomson's rule, then there is nothing whatever to say against this point of view. It will lead to the solution of the problem. But it would be wrong to believe that this is the only way of looking at the matter. What will take place depends on the free energy of the reaction, and this may be found by measurements of e. m. f's or by purely chemical research. The former viewpoint has been prominent in the past. Dr. Bancroft is right in pushing the chemical viewpoint now to the front. What we need more than anything else is a broad way of looking at things. Only by attacking a problem from all sides can we master it. It is to be hoped that Dr. Bancroft's lecture will contribute toward this end.

Recent Progress in Ore-Dressing.

It is commonplace to-day to say that this era is an era of growing complexity. Indeed, complexity is common to all subjects, and as we have repeatedly pointed out on these pages, it is a logical outcome of evolution. All things, from a zoöphyte to a monster blast-furnace, are subject to this great doctrine. This complexity affects our social life. It affects our religious thought. It also affects our commercial world. Science has revolutionized theoretical dogma and applied science has created our wonderful industrial structure. In all things, then, we can look for its profound influence. Metallurgy has advanced in the past hundred years, by leaps and bounds, from a simple to a wonderful art. All its branches have expanded. But of all, ore dressing, we believe, has shown that great and astounding growth that is most representative of our American industry. It is an example of complex application of scientific principles.

Ore dressing takes the crude ore, subjects it to a mechanical process, and makes a high-grade product from low-grade ore. Its *raison d'être* is its cheapness of treatment. The low cost of ore dressing compensates for its high losses. Any improvement in such a basic process vitally influences all the other subsequent processes, because it makes from low-grade ores high-grade products available for the latter processes. The perfection of the high-power crushing machinery has rendered the first work of mechanical segregation of the constituent minerals cheap and efficient. The improvement in "sizing" or separating these minerals in various classes, according to size, has brought about increased efficiency of the old-time apparatus, such as the Hartz jig and vanner. Next, the introduction of the shaking riffled table, such as the Wilfley, has worked a revolution in the concentrating mill by filling a long-felt want. All these improvements were simple developments along the old line of separation by making use of the fact that particles of minerals of different specific gravity and same size fall through water at different speeds. Concentrating experts are, however, using at least four different properties of minerals—magnetic permeability, electric conductivity, susceptibility to chemical action, and susceptibility to being "wetted" by oils. All these developments are a bit startling.

The magnetic separator developed for the iron business could not succeed in face of discoveries of the cheap Mesabi ores. But it has been intelligently applied to the zinc ores of the Franklin mine, New Jersey, and has greatly enhanced the money value of that large deposit. It has also been applied with success to the complex zinc ores of the Rocky Mountains and Wisconsin. Copper ores are often well treated by it, and, in fact, it has found a wide range of application in the whole field. Its rival and coöperator, the electrostatic generator, has been made also a practical machine. The "Blake-Morscher" electrostatic separator is used in commercial work in large mills in Denver, Park City, Butte and Wisconsin. It is a distinct success. Very favorable reports are heard of another electrostatic separator, the "Dolbear," developed in Boston, which is a bold innovation, in using the high-tension transformer instead of the electrostatic generator for the exciter of the separator. This machine has been evolved from the laboratory stage by the aid of some distinguished electrical engineers. We hope to give it in the future the prominence it deserves in our columns. The Elmore oil separator has a peculiar sphere of action in the ore-dressing field. Some minerals are easily "wet" by crude oils and some are less easily so affected. Such so-called "grease processes," of course, can be nicely applied where everything else fails. One of the original grease processes was discovered at the Kimberly diamond mines by a boy, who, while eating his lunch at work, accidentally dropped a piece of bread, "butter-side down," on the traveling belt on which the diamond-bearing clay passed. He found that where the grease was, there also were the diamonds. For some time this youngster enjoyed "easy money," and was finally only persuaded for a consideration to tell his secret.

Another prominent development is the "acid-flotation process," used on the complex sulphide ores of the Broken Hill, Australia. These enormous deposits of zinc-lead ore have made large tailing piles of great potential value. The "Delprat-Potter" and the "Bradford" process have solved the question of treating them, and the zinc ore market of the world is affected by this discovery. The treatment of these complex sulphide ores is thus being worked out by a complex method, it would seem. Almost all these methods are really due to original scientific discoveries. Science, simple in itself, as all philosophy is simple, can be infinitely expanded. Its expansion to complexity is natural and beautiful. This brief and imperfect review of human achievement in this line of complexity leads us to believe that the next decade will see more advance in this line. Such advance is but an evidence of the spirit of the age. This is an age of metallurgical industry, and we feel proud of our title as indicative of just the spirit which it is our sincere desire to represent.

Editorial Notice.

Owing to the considerable space allotted to the report of the Bethlehem meeting of the American Electrochemical Society, this issue is somewhat circumscribed in the scope of its contents, and portions of our regular departments had to be reserved for our next issue. The second part of Dr. Keller's paper on labor-saving devices in laboratories and the conclusion of Mr. Ladoff's article on the electrochemistry of the electric arc, will also be published in that issue.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

Primitive Tin Mining of To-day.

While exploring a quiet cove, within 10 miles of Land's End, with a view to finding a place for a bath, on a recent holiday, I stumbled upon an isolated metallurgical industry of a very primitive order. A solitary man—the industry had been carried on by him on that spot for some seven years—was to be seen collecting in buckets the darker patches of black-looking sand and carrying these to little heaps. Near by, when tin was far cheaper and metallurgical methods infinitely crude, the refuse from a neighboring mine had for some years been dumped over the cliff into the sea. As a result the sand contained innumerable black nodules of tin. This solitary worker collected the blacker looking sand, afterwards washing it in baffle boxes through which a stream of water ran. The lighter particles of silica and crushed sea shells were carried away, leaving a residue of almost pure tin. By working day in and day out in all states of weather, this man managed to recover about a ton of tin per annum, for which he received about £90 by selling it in small quantities at a time. Industrially the matter has no immediate financial importance, but looked at in another light, it is curious to think of the metallurgical wealth of the world wasted by the present and earlier generations. Perhaps our successors may find much wealth in the scrap and rubbish heaps of to-day which are now the resort of those low down in the industrial scale. To-day the Chinaman forages among abandoned workings on Californian gold fields, and I have seen on the Durham coast, when a good steam coal (that is, good for Durham) was fetching $3 per ton, women and girls picking lumps of coal from a beach upon which the sea had returned a portion of the colliery refuse dumped into it a few hours before. Perhaps, among the now despised refuse of foundries, furnaces, mine tailings and rubbish heaps of alkali works, the scientist of the utilitarian to-morrow may peg out claims for remunerative working. Ideally there should be no waste, but the practice of to-day is another tale. It is for the scientist to begin to consider these things. Of all wealth which the world possesses, mineral wealth is the most ephemeral, for though the fellaheen of to-day grows his corn, gathers his dates, and makes his mud bricks as it was in the days of the Pharaohs, the sources of the world's then mineral wealth are merely the subject of enlightened conjecture.

The Recent Liege Congress.

Immediately after mailing my last letter I received the complete set of papers read at the Congress, and was surprised to find that a paper by Prof. Le Chatellier had not received extended notice in the British technical press. Every metallurgist knows how to prepare metallic specimens for microphotographic purposes. M. Le Chatellier, therefore, claims for his paper nothing new in the way of discovery, but a description of carefully conceived methods of preparing the specimens, so simple and exact that by following them excellent specimens may be prepared by elementary students.

Obtaining a Flat, Smooth Surface.—Specimens detached from the main block with a saw or hammer are best treated with an emery wheel. To avoid bringing about hardening of the specimen by the percussion use a high-speed wheel, and do not press hard. In the case of tempered steel, a slow speed and frequent mostening are necessary to avoid letting it down. In spite of precaution, a thin external skin or layer of the specimen is altered in condition by the friction of the wheel. This must be removed by emery paper, applied by hand. To make the process more rapid, moisten the paper with turpentine. To delay it, grease the paper, which also causes it to scratch less. Angles should be rounded off on the emery wheel to facilitate polishing.

Finishing.—Emery paste should be prepared by the operator, the emery of commerce containing grains of unequal size. Proceed as follows:

First Application of Emery.—Emery powder is used, and that which is passed through a sieve of 2600 meshes to the square centimeter and is held on a sieve of 4900 meshes to the square centimeter is retained. The grains thus selected will be 1/10 millimeter in diameter.

Second Application.—Emery paste. The finest commercial emery paste is washed by a stream of water ascending, and the portions taken along by the stream are used. The author uses an apparatus thus described: A glass tube 40 cm. long to 50 mm. in diameter is closed at either end with corks; the lower cork is pierced by the pipe of a glass funnel, of which the trumpet is inside the large tube. The mouth of the funnel is covered by a piece of metal gauze. The water enters through this funnel under pressure. A short distance above the funnel is placed a double cone of tinfoil, about three times as long as the diameter of the base, and cutting it in half, thus obtaining a segment of a cone, or funnel of wide mouth, and a smaller cone. The segment is placed in the large tube, smaller end downwards, and the small cone inside it point upwards, in such a manner that the plane of the base is in the same plane as that of the upper end of the segment. A long glass tube, about 5 mm. in diameter, is led through the upper cork of the large tube to just above the point of the small cone, and leads to it the emery. The emery slides over the cone into the ascending water. The finest grains are carried to the upper cork, and find egress through a tube shaped like the letter S, the top hook of the letter entering the bottle. The curve of the lower hook of this tube has a small hole in it, through which the water and emery in it passes into a receiving bottle. The end of the hook should be carried up some distance above the large tube. The level of the liquid in this ascending pipe gives a measure of the pressure of the water employed, and this pipe is marked after experiment, to enable the speed of different washings to be readily adjusted by raising or lowering the water supply bottle. The tube through which the emery is let into the washing or large tube should be from 3 to 5 mm. in diameter (inside). The washings are received in a bottle having two apertures, one leading to the side to bring the water in at an angle, and the other the ordinary orifice at the top, with a tube to carry off the water.

Third Application, Alumina.—M. Le Chatellier refers to a former description of the method of preparing alumina of ammoniacal alum as a base, and washing by the process used by Schlesing for separating out clay in earths. He recommends that the alumina be beaten in a mortar to separate the grains. It is then washed with water acidulated with one in 1000 of nitric acid, then with distilled water, and finally with water to which 1 or 2 cubic centimeters of concentrated ammonia per litre has been added. Generally, after a certain number of washings with the water acidulated with nitric acid, the alumin is found to remain in suspension, *i. e.*, it is sufficiently washed. To obtain the alumina use a large glass tube, somewhat similar to that of Schlesing. The tube should be 50 cm. long, and holding 1 litre. The lower end is conical, with a slope of 3 to 1. In it is an opening 3 mm. in diameter at the most, so that air may not enter. The top of the tube is

connected to a smaller pipe, having a copper top and orifice for sucking.

The mixture of alumina and washing liquid is drawn up into this tube by exhausting the air, and the top is then closed. The alumina falls to the bottom and the top is then opened slightly to let it drop, at the rate of one drop per 10 or 20 seconds. The grains emitted during the first quarter of an hour are coarse, and up to 3 hours from opening the top they are unsuited for the highest class of finishing, though useful for rougher work. The best material is precipitated after 3 hours dropping. The tap may then be opened full after 3 hours and the rest taken out. A spray bottle is the best vessel to keep the mixture in.

Fourth—Cloths, etc., for Using with the Pastes.—M. Le Chatellier uses very fine flannel stretched on glass and clamped down at the edges with slips of wood. To cause the powders to adhere to the stuff he uses a mixture of oleix soap and manganate of soda, with a little glycerine or black soap. The soap solution should be filtered to extract grains. The soap should be of a kind remaining soft. For the final polish with alumina, revolving discs may be used, either of wood, covered with fine cloth, or felt.

By these methods specimens 15 mm. in diameter may be surfaced and polished in a quarter of an hour. The best size for specimens is 15 mm. diameter by 10 mm. thick.

Treatment of Alloys with Reagents.—Numerous experiments have been carried on in M. Le Chatellier's laboratory for the separation of alloys. M. Igewsky has experimented with coloring matters, and finds that only the nitrogen derivatives gave interesting results.

The use of a 5 per cent solution of picric acid in alcohol has become general. M. Kourbatoff has investigated alcohol and advises a 4 per cent solution of nitric acid in amylic alcohol as to the picric acid. It is also useful in combinations to color out the constituents of steel, for instance: Four per cent solution nitric acid in ordinary alcohol, 1 pint; saturated solution of nitrophenol, 3 parts; with color out, troostite and like constituents, leaving the rest uncolored.

M. Le Chatellier finds that cementite may be easily colored by the addition of boiling alkaline solutions with the addition of any oxydizing agent, especially picric acid.

A 25 per cent solution of caustic soda, plus a 2 per cent of picric acid, warmed to 100° C. in a water bath is recommended. This reagent does not color deeply, and the colored surface is easily removed by polishing slightly.

The Microscope.—M. Le Chatellier has previously recommended the use of the mercury vapor lamp for microphotography, the ultra-violet rays being excluded by a bath of acid sulphate of quinine. The lamp is, however, very fragile. He prefers the use of a Nernst lamp with two filaments, taking 1 amp. per filament. The lamp should be adjusted so that the filaments superpose their rays one on the other. A little more clearness of the image is gained by using isochromatic plates and interposing a 1 per cent solution of picric acid and 1 cm. in thickness, but with Zeiss apochromatic objectives and ordinary plates, the result is good enough for ordinary work.

He recommends the use of diaphragms placed before the source of light, directly under the objective, as near as possible to the back lens. Various diaphragms may be mounted on a circular plate for convenient use; 5 mm. is a suitable diameter for the orifice. By using them slightly out of the direct line irregularities of surface on the specimen may be accentuated.

M. Pellin has adapted to his microscope an adjustable table for the specimen, controlled by thumb screws as used on ordinary microscopes. The beam of light is now reflected by a prism which can be moved so as to direct it either on the eyehole or the lens.

With the mercury lamp the time of exposure is 15 minutes with the horizontal photographic chamber, three times as long with the vertical chamber. With the two-filament Nernst lamp the time of exposure is 2 and 5 minutes for brilliant steels. It is 10 to 30 minutes for non-reflecting bodies, such as glasses, slag, etc.

Zeiss' apparatus has facilities for the adjustment of the two lenses, which permit of a very flat image being obtained.

Sterilization of Sewage Effluents.

In my letter, published in the January issue of Electrochemical and Metallurgical Industry, I dealt with the general outlook concerning the use of sodium hypochlorite, prepared electrolytically as a sterilizing agent. I am not aware that any new works are in operation since I wrote. A paper read by Dr. S. Rideal before the Royal Sanitary Institute, discusses the properties of various agents, and deals satisfactorily with pretty well every aspect save that of the actual cost. The sparing solubility of ozone was pointed out, and its practical limitation as a finishing agent for previously filtered canal or river water emphasized. Dr. Rideal expressed his own preference for chlorine and its oxides as easily soluble, generally more manageable and as powerful as ozone, when "the main part of the organic matter has been removed or reduced." "Although these processes," Dr. Rideal says, "are commonly called chlorine methods, it must be remembered that the purification is mainly effected by oxygen liberated in an active state through the action of chlorine on water, the proportion of the element that can serve in this way being termed 'available chlorine,' as distinguished from that present in chlorides, such as common salt, which is almost inert. The amount of oxygen liberated by chlorine itself, as in the addition of chlorine water or the gas, is doubled when it is present as hypochlorite, and my experiments indicated that the oxygen value of the electrolytic solution, containing chloride oxides and other compounds, was still greater."

The arsenious acid test cannot be regarded as wholly satisfactory for the testing of hypochlorite solutions, as Dr. Rideal states that in a large number of trials in which the sterilizing medium was added in varying amounts, showed that nearly a constant proportion, about 60 per cent, of the available chlorine was taken up almost immediately, while about 40 per cent remained and declined more gradually, pointing distinctly to the chlorine existing in the reagent in two forms, one which acts at once on readily putrescible matter, the other remaining to attack bacteria and resistant organic substances.

As regards the mineral acids, their employment in a dilute form kills most organisms, and 4 grammes of sulphuric acid per gallon will sterilize typhoid bacilli in the drainage from an isolation hospital.

The first place is thus given to hypochlorite solutions, in regard to the preparation of which Dr. Rideal is silent. The cost depends partly upon the electrochemical efficiency, partly upon the life of the anodes, partly upon the stability of the solution produced, and partly upon the ratio which exists between the amount of salt which is converted into sodium hypochlorite, and the far larger quantity which remains unconverted and is wasted.

One important factor is due to Dr. Rideal's investigations, and that is a preliminary scientific investigation of the amount of hypochlorite required, which is that *the amount of oxygen absorbed in 5 minutes, multipled by 1.7, gives the amount of available chlorine required in parts per* 100,000.

Market Quotations During August.

Some slight changes, mostly of the downward order, have to be chronicled concerning the chemical trade during the month. Bleaching powder, 35 per cent, is 2s. 6d. cheaper at £4.7.6. Sulphate of ammonia is also cheaper at £12.11.3, as against £12.17.6, while the coal tar products have receded fractionally. Borax is now fetching £13 per ton, an increase of £1; copper sulphate has risen to £22 per ton. Shellac is steady at £9 per cwt.

With regard to metals, copper reached, on Aug. 26, the high price of £72.10; the demand being in excess of the supply, prices are being maintained at a high level. Tin has been

somewhat irregular, reaching £152 per ton on Aug. 2, falling to £148.15 within a week, but subsequently mounting to £152.10. There has since been another reaction in the price, but owing to the scarcity of supplies a further rise is expected. Lead has closed at £14.15; Cleveland pig iron has risen to £2.8.4½, while the growing demand for all classes of material indicates a marked improvement in the steel and iron trade.

London, Sept. 5.

CORRESPONDENCE.

Lead Poisoning.

To the Editor of Electrochemical and Metallurgical Industry:

Sir.—The International Labor Office of Basel (Switzerland) have invited an international prize competition for the prevention of lead poisoning, and are desirous of making this competition known. They have asked me to assist them in giving their proposition a widespread publication in the United States.

Knowing that your paper will be an excellent means for reaching a great many persons interested in the above competition, I trust that you will publish the conditions of the prize competition of which I beg to enclose you a copy herewith.

To those of your readers who are not acquainted with the aims of the International Labor Office the following data may be of interest:

The International Labor Office, which was organized by the international Association for Labor Legislation, began its work in May, 1901. This association was founded by persons advocating the legal protection of workmen, among whom were prominent statesmen and scholars of Europe. Sections of the association have been formed in Austria, Belgium, France, Germany, Great Britain, Hungary, Italy, Netherlands and Switzerland.

The International Labor Office is subsidized by the governments of the following countries: United States, Belgium, France, Germany, Hungary, Italy, Luxemburg, Netherlands, Sweden and Switzerland.

According to its rules the International Labor Office has to serve as a scientific organ, and it has been entrusted with the task of preparing and publishing a bulletin, containing an account of all the new laws concerning the hygiene and safety of the working classes.

Due to the efforts of the International Association the Swiss Federal Council called out an international labor conference, which took place in Berne in May, 1905; its special object was to discuss the abolishment of the use of yellow phosphorus in the manufacture of matches and the prohibition of night work for women in the industry. F. G. Hartmann.

New York City.

[According to the printed rules of the competition the following prizes are offered:

One prize of $1,200 for the best treatise on the prevention of lead poisoning in the operation of mining and milling lead ores or ores containing lead. One prize of $2,400 for the best treatise on the prevention of lead poisoning in smelting and refining works. Two prizes, viz. one first of $600, one second of $360, for the best treatises on the prevention of lead poisoning in the chemical application of lead, as in white lead works, manufacture of other lead paints, of electric accumulators (storage batteries), etc. Four prizes, viz.: one of $360, one of $240, two of $180 each, for the best treatises on the prevention of lead poisoning in the trades of house, ship, coach-painting, interior decoration, varnishing and the like. Four prizes, viz.: one of $360, one of $240, two of $180 each, for the best treatises on the prevention of lead poisoning in those trades where raw and manufactured lead are consumed or handled on a large scale, as in type foundries and printing offices.

Each treatise to contain a systematic review of the special causes giving rise to lead poisoning, in conjunction with a description of the various processes of manufacture, pointing out the dangers occasioned at every phase of procedure, including handling and transportation.

Reference to be made also to the causes due to working at places in which a prolonged occupation is liable to affect the health, to want of cleanliness, lack of proper guidance and instructions, carelessness, poor and inadequate food, irrational way of living and unhealthy dwellings of the workmen. In connection with the statement of the causes of lead poisoning, measures for their prevention are to be proposed.

Substantial evidence should be given for the proposed preventives as regards their technical, hygienical and economical feasibility.

The comparative injuriousness of the different phases of manufacture, as well as of the conditions referred to above, must be demonstrated as far as possible by a properly graduated classification of the risk of lead poisoning, from the highest to the lowest degree.

In proposing new installations or alternations of the existing mode of operation, the probable increase or decrease of expenses incurred by the change should be approximately stated, *e g.*, in proposing mechanical appliances to supersede manual labor the primary cost of these, as well as the increase of working expenses by depreciation and interest of the capital invested would have to appear, as well as the saving of wages or other factors of economy, viz.: the avoidance of fluctuations and changes in the working staff and, in consequence, the maintenance of a properly trained crew with a corresponding improvement of their capacity.

It is desired that the treatises should promote the development of the present provisions of the various States by outlining or drafting legal or administrative regulations or suggestions to the proper authorities, aiming at the realization of the preventive measures proposed by the competitors. Short precepts against the danger of poisoning might also be given preferably in a form suited for posting in workshops, building grounds, etc.

A compilation of the existing government regulations may be found in the volume *Gesundheitsgefahrliche Industrien*, edited by Prof. Stephen Bauer (Jena, G. Fischer, 1903), and in the *Bulletin des Internationalen Arbeitsamtes*, 1901-1904; which publications can probably be had at the libraries in large cities.

A clear and concise summary of the measures proposed by the competitors is to be given at the end of the treatise.

The papers may be written either in English, French or German. Already printed books cannot be taken into consideration by the jury. The ready manuscripts must be put in an envelope bearing only a motto, and lodged with the International Labor Office at Basel on or before Dec. 31, 1905.

The full name and address of the author should be stated under a separate sealed cover bearing on its outside the same motto as above.

Contributions arriving later than Dec. 31, 1905, will be excluded from the competition.

By the award of a prize the International Labor Office is entitled to publish a treatise, leaving, however, its author the exclusive property; the office may also concede to the authors the right of publishing their treatises. Manuscripts which are not secured for publication will be returned to their authors.

In case the jury should not see fit to award the total sum of $6,480 reserved for the prizes, the remainder shall be employed upon recommendation of the jury by the "International Association for Labor Legislation," for other purposes concerning the hygienic welfare of the working classes.

All letters, inquiries and other matters pertaining to this competition are to be addressed to the International Labor Office at Basel, Switzerland.]

BETHLEHEM MEETING OF THE AMERICAN ELECTROCHEMICAL SOCIETY.

The eighth general meeting of the American Electrochemical Society was held in Bethlehem, Pa., from Sept. 18 to 20, and was very greatly enjoyed by those who attended it, although the inclement weather spoiled to some extent the elaborate preparations which had been made for excursions around Bethlehem.

On the forenoon of Sept. 18 a directors' meeting was held at the Eagle Hotel, at which some important decisions were reached, as was announced by Dr. W. D. Bancroft in his speech at the banquet. In the first place, the intention is to hold in future only one meeting a year, but it has not yet been decided whether the spring or the autumn meeting is to be retained. On the other hand, this decision does not prevent holding a second meeting jointly with one of the older national engineering societies, as the American Chemical Society, the American Institute of Electrical Engineers and the American Institute of Mining Engineers. Dr. Bancroft transmitted to the society an invitation from Cornell University to hold the next meeting in Ithaca, in May, 1906.

An important decision reached at the directors' meeting was that the society will use some of its funds—probably in the beginning $100 a year—to encourage research work. For this purpose a circular letter will soon be mailed to all members to make suggestions as to subjects which need research. It is hoped that a valuable list of suggestions will thereby be obtained.

BETHLEHEM MEETING OF THE AMERICAN ELECTROCHEMICAL SOCIETY.

MONDAY SESSION.

The first session was held on Monday afternoon in the chemical laboratory of Lehigh University. Dr. J. W. Richards, as chairman of the local committee, welcomed the members to Bethlehem, and introduced President Drinker, of Lehigh University, who in a felicitous little speech expressed his pleasure at the fact that his first public official act as president of the university was to welcome the members of the society to the freedom of Lehigh. Dr. W. D. Bancroft, as president of the society, pointed in his reply to the happy combination of educative and commercial activity in Bethlehem, as represented by Lehigh University on one side and by the steel, zinc and cement works on the other side. Bethlehem had provided the American Electrochemical Society with its first president, Dr. J. W. Richards.

Colloids.

A brief note by Prof. W. S. Franklin and Mr. L. A. Freudenberger was presented by Mr. Freudenberger. The leading idea of their experimental research was to get some distinct idea of the nature of a colloidal solution, by spinning

a tube containing the colloid at a high speed. The hope of the authors was that the centrifugal force would produce a new condition of equilibrium within the colloidal solution; this new equilibrium would then be a function of the speed at which the tube is revolved, and it would be possible to study, by optical means, the new condition of the colloid as changing from point to point when getting away further from the axle of rotation. This would then have given some idea of the size of the particles, etc. However, these hopes were not fulfilled. It is true that if the speed of revolution is high enough, a new equilibrium results, but this is simply that the particles are first thrown down at the end of the tube and this is followed by a sort of growth of the precipitate along the tube. Nothing whatever happens until the centrifugal force is great enough to bring about at the terminal of the tube the precipitation of a nucleus, which then results in further precipitation. The paper was briefly discussed by Dr. J. W. Richards and Dr. W. S. Franklin.

The Chemistry of Electrochemistry.

An experimental lecture of great interest was presented by Dr. Wilder D. Bancroft. The object was not to propose a new theory but rather to present a point of view which has been generally neglected in the development of electrochemistry. The fundamental idea of Prof. Bancroft is that the action of the current in an electrolytic cell is to bring and discharge the ions at the electrodes. What then happens—everything that happens over and above the discharge of the ions—is a question of pure chemistry, and should be looked upon as a purely chemical problem. To understand an electrochemical reaction it is of fundamental importance to supplement the investigation by parallel chemical work.

"Let us consider first the reactions at the cathode. If we pass a current through a slightly acidified solution of copper sulphate we get the precipitation of metallic copper. This is merely the normal action of the current setting free the cation, copper, at the cathode. If we acidify the solution still further, adding sulphuric acid in one case and nitric acid in another, we find that a given amount of nitric acid will prevent the precipitation of copper, while much more sulphuric acid must be added to cause the same effect. The reason of this is clear when we consider the chemistry involved. Nitric acid attacks copper readily and sulphuric acid does not. While this is perfectly obvious when stated in this way, it has not been obvious enough in the past to induce anyone to test quantitatively the relation between the decreased current efficiency in a nitric acid solution and the rate of corrosion by that particular solution. We know that the current efficiency increases with current density, which is just what we should expect if the chemical remains constant; but more than that we do not know."

WILDER D. BANCROFT,
Pres. American Electrochemical Soc'y.

The difficulty of depositing sodium from an aqueous solution is due to the rapid chemical action of water on any sodium that may be deposited. To precipitate sodium from the fused salt the temperature must be high enough to have fusion, but must not be raised so high that the sodium would react with the bath. Sodium amalgam reacts with water much less rapidly than does metallic sodium; therefore, it is possible to form sodium amalgam electrolytically by using a mercury cathode.

If a very high current density is used in an aqueous caustic soda solution with a lead cathode, a black cloud is given off from the cathode. The fact is that a sodium-lead alloy is formed which breaks down practically at once, scattering pulverulent lead through the solution in a black cloud. That this is the correct explanation was proven by Haber, who supplemented this electrochemical experiment by chemical research, and showed that a sodium-lead alloy, prepared chemically, reacts exactly in the same way when put into water.

"If we electrolyze a solution of copper sulphate plus zinc sulphate we get a precipitation of copper. The reason why no zinc can precipitate as such becomes clear when we dip a rod of zinc into a copper sulphate solution. The copper precipitates and some zinc dissolves. When no other disturbing factors occur, we find that the more rapidly one metal precipitates another from solution, the less readily will that metal be precipitated electrolytically from a solution containing the two metals. Thus more care has to be taken in separating silver from copper than in separating copper from zinc or cadmium. There are some apparent exceptions to this, but a study of the chemistry involved clears up matters. In sulphate, nitrate or acetate solutions, massive aluminium or massive nickel will not precipitate copper. Under certain conditions iron will not precipitate copper. In all of these solutions copper precipitates electrolytically before these other metals. If we examine into the matter we find that while nickel, for instance, does not precipitate copper, neither does copper precipitate nickel. We are, therefore, not dealing with a reversible reaction, and the presumption is that the conditions are not as stated. As a matter of fact, we find that the aluminium, the nickel and the iron are covered with a surface film, so that the metals do not come in direct contact with the copper sulphate solution at all. With the iron a mere scratch suffices to break the film and to cause the precipitation of copper."

With respect to the electrolytic precipitation of alloys it is very important to study the chemical equilibrium between the alloy and the solution.

"The electrolysis of a solution of the sulphates of zinc and copper has been discussed as a separation of copper from zinc. We may also consider the electrolysis of an acidified copper sulphate solution as a separation of copper from hydrogen. Since the copper precipitates before the hydrogen we should expect this to mean that hydrogen precipitates copper from solution. At first sight this seems not to be true. One can bubble hydrogen through a copper sulphate solution forever without precipitating any copper. We are not doing our chemical experiment under the same conditions that we used in the electrochemical experiment. In the latter the copper was precipitated at an electrode. If we place a piece of metal, preferably platinum, in a copper sulphate solution and pass in hydrogen gas we shall get a reduction by the hydrogen to metallic copper. It is this apparent inertness of hydrogen gas which has led to the conception of nascent hydrogen. In all cases where we have effects due to so-called nascent hydrogen, we have a metal present, and the effect is either due to the metal or can be duplicated by hydrogen gas in contact with a metal."

With respect to the "excess voltage" which is required to set hydrogen free at cathodes of certain metals over that required on other cathodes, Dr. Bancroft made the following suggestion:

"Zinc is a metal giving a particularly high excess voltage. It is owing to this that it is comparatively easy to precipitate zinc or cadmium from a solution which is perceptibly acid. This may be connected with the fact that pure zinc does not dissolve readily in acid solutions; but beyond that our knowledge does not go as yet.

"If we electrolyze the salt of a metal which can have a varying valency we may meet special difficulties, but they all become intelligible when we consider the chemistry of the solutions. If we start with a solution of ferric sulphate or

chloride we do not get metallic iron precipitated, because iron and ferric sulphate or chloride react to form the ferrous salt. Since the equilibrium is reached only when practically all the ferric salt has disappeared, it is necessary to reduce the ferric salt practically completely to ferrous salt before metallic iron can be obtained."

For zero current density the electrochemical and the chemical equilibrium must be the same for all reversible reactions. For any finite current density we have to consider reaction velocities. In general we shall diverge farther from the chemical equilibrium the higher the current density. This is merely another way of saying that the so-called primary reaction is favored by low-current density.

Dr. Bancroft then discussed in the same way a great many reactions at the anode, especially the different products which can be obtained in the electrolysis of chloride solutions, etc. The success of the investigations of Foerster and his collaborators in clearing up these problems has been due to the fact that they studied the chemical and electrochemical phenomena simultaneously.

With respect to sulphate solutions Dr. Bancroft referred to the following point, which emphasizes our ignorance:

"In Germany the oxygen evolved during the electrolysis of sulphuric acid is believed to come from the water, according to the equation

$$SO_4 + H_2O = H_2SO_4 + O.$$

In France the oxygen is supposed to come from the sulphate radical itself, according to the equations

$$SO_4 = SO_3 + O$$
$$SO_3 + H_2O = H_2SO_4.$$

So far as I know, no one has ever brought forward any proof which would enable us to decide between these two views. We know that solid ammonium or potassium persulphate breaks down into sulphate, sulphur trioxide and oxygen, which is an argument in favor of the French point of view. The formation of hydrogen peroxide from persulphuric acid falls more in line if we consider the oxygen as coming from the sulphate radical. On the other hand, the formation of persulphates seems to be an argument on the other side. Whatever the final decision may be, I wish now merely to emphasize the fact that this is a problem which has not been faced in the past, largely because we have kept our chemistry and our electrochemistry more or less apart."

Finally, Dr. Bancroft referred to the following point:

"It has been found that electrolytic reduction takes place more readily at certain cathodes than at others, zinc, copper and tin being the best in certain cases, lead in others. It appears to be a specific action of the cathode in each case. In the Boehringer patents for reducing nitrobenzene it was stated that one could substitute a platinum cathode for a tin or copper cathode, provided one added a tin or a copper salt to the solution. It looks, therefore, as though we were really dealing with the chemical action of the pulverulent metal on the substance to be reduced, and that the current merely regenerated the reducing agent. This brings out again the importance of studying the electrochemical phenomena with special reference to the chemical phenomena. Recent work of Tafel shows that some of the mysterious changes in cathode efficiencies are due to the precipitation of minute quantities of platinum, and we have long known about the disastrous effects of platinum on storage cells."

Dr. Bancroft's general conclusion is that we get a clearer view of the subject as a whole if we consider the chemistry of electrochemistry, and that this point of view is valuable in showing us concrete instances of research work which ought to be done.

Dr. Bancroft's paper, which was illustrated by a great many experiments, was discussed in a lively way by Mr. Carl Hering, Mr. Anson G. Betts, Dr. J. W. Richards and Prof. C. F. Burgess. Mr. Hering read a communicated discussion of Mr. C. J. Reed, who did not agree with the point of view of Dr. Bancroft, and maintained that the only right way to look at the question which reaction will happen in an electrolytic cell, is to find the energies of reaction corresponding to the different reactions which would be a priori possible. The value of the energy of reaction (or of the voltage which is proportional to it) decides whether a reaction will go on. This rule was applied by Mr. Reed to a discussion of several examples from Dr. Bancroft's paper. Prof. Burgess thought that the value of Dr. Bancroft's point of view is just the absence of any electrochemical theory. His point of view forces us to get right down to facts.

Metal Deposition.

A very suggestive paper by Mr. Anson G. Betts was then presented. The object of this paper was to find the underlying principles which decide whether an electrolytic metal deposit will be good or bad. Mr. Betts first took up several suggestions, which have been made to explain in special cases the specific effect of additions, etc., on the quality of a deposit. In this way he discussed the effect of colloids, the effect of reducing agents, the influence of the strength of an acid and of the alkalinity of a base, etc. He described several experiments in which he had tested his former suggestion, that the e. m. f's. set up on the ridges and in the hollows of an electrodeposit, due to the difference of concentration at the two places, might decide the quality of a deposit.

Mr. Betts then referred to the assumption that differences in crystallization habits of the metals might be the causes of different forms of cathode growths. But he pointed out that we are not able to separate the metals in two groups, one of which crystallizes according to one system and gives, perhaps, good deposits, while another group crystallizes in other habits and gives non-solid deposits. Mr. Betts, therefore, concluded that we cannot assign to the crystallization habit of a metal the controlling force of the character of deposits made with it. Moreover, there is no evidence that many of our so-called crystalline deposits are crystalline at all. "Just as a rough pile of bricks may look like crystals, while they are alike in shape, just because an agency has been at work making clay into similar shapes, so some agency, for example, changes in concentration, may be at work in shaping a metal deposit of similarly shaped particles. We have all seen streaked electrodeposits with vertical streaks traversing the surface. If we also happened to have some other agency than the rising current at the cathode at work, only in a direction at right angles thereto and parallel to the surface, the surface would be laid off in little rectangles, which might be assumed, a few times at least, to be crystals." There is in many cases a striking similarity in appearance of electrolytic deposits with rocky cliffs and quartz.

Mr. Betts then discussed the counter e. m. f. of polarization under varying conditions in electrolytic cells. For instance, in a lead fluosilicate solution, containing 5.2 grams of lead and 3.5 grams of fluosilicic acid per 100 cc., the polarization of e. m. f. differs if an addition of gelatine is employed or not (the addition giving a smooth, hard deposit). The increase of potential at the cathode in this case is about 0.007 volt when gelatine is added. Mr. Betts put up the question, what becomes of the energy which this increased voltage represents, and which amounts to about 1.7 kw-hours per ton of lead produced.

Before he answered this question, Mr. Betts gave a table, in which he divided the metals into two great classes: First, those which yield solid deposits with appropriate solutions, and, second, those which produce loose deposits. From this table he concluded that the one distinguishing property between these two groups of metals is their hardness, and he gave the general rule that the harder a metal the better the deposit. An approximate value of the hardness may be found by the rule of Bottone, according to which the hardness is

proportional to the specific gravity divided by the atomic weight. Mr. Betts then discussed the influence of valency in the phenomena of colloids, and expressed the belief that in electrolytic deposition the effect of the basic radical will manifest itself in causing more or less firm cohesion, according to its valency.

The general theory which he, therefore, proposes is that a hard metal will separate in solid, compact form, and a soft metal will deposit in loose crystalline form. When the hardness is intermediate the valency of the metal becomes a determining factor, high valencies producing solid deposits and low valencies loose deposits. When we come to that part of the scale of atomic density (specific gravity divided by atomic weight) where it is questionable whether a deposit may be solid or not, it is quite possible that factors of less importance will assume a more important rôle.

If a metal is not hard of itself, it is possible to deposit it in smoother form if it can be made harder. This is, according to the author's view, the case in lead depositing, as the result of the addition of gelatine and the excess of consumed energy, amounting to 1.7 kw-hours per ton of lead, as stated above, is consumed in hardening the lead.

The author then discussed the rôle which surface tension plays. He proposed that the greater the hardness of a metal, the greater is its surface tension, and as a consequence in depositing a hard metal we have much more potent forces at work keeping the surface smooth than in depositing soft metal. When surface tension comes strongly into play, the growth will not be by the application of thin layers of crystal masses, with projecting points forming the foundation of more points, but by the application of layer after layer of uniform thickness and non-crystalline structure, so that the effect of high-surface tension is to smoothen the deposit.

Mr. Betts then suggested another general rule, that is, that the greater the hardness or the cohesion of the material, the less its solubility. He also expressed a belief that there is some relationship between surface tension and valency. In passing over to the surface tension of metals, as influenced by solvents and solutes, Mr. Betts arrived at the rule that if the surface tension of an immersed solid is greater in the solution than in the solvent it follows as a result that dissolved substances in the solution will harden, and consequently smoothen an electrode deposit.

This is about the gist of Mr. Betts' long and interesting paper. For the great many details contained in the paper the reader must be referred to the full paper, which will be published in the Transactions of the Society. The paper was discussed at some length by Messrs. Burgess, Franklin and Richards. Prof. Burgess showed some micrographs of electrochemically-deposited iron. He stated that the majority of electrolytic deposits show crystalline structure. Several speakers doubted whether some of the generalizations of Mr. Betts, for instance, on the relation between hardness and solubility, could be maintained in such a broad form as stated.

In the evening the ladies' committee gave an informal reception at the house of Prof. and Mrs. J. W. Richards. This occasion was very greatly enjoyed. Afterwards there was a smoker at the club house of the Lincoln Republican Club, just opposite the old Moravian Church yard, which holds, besides many other graves of historical interest, that of the "Last of the Mohicans."

TUESDAY MEETING.

Aluminium as Reducing Agent.

The first paper of the Tuesday morning session was by Dr. Oliver P. Watts, on the use of aluminium as a reducing agent. In the absence of the author it was presented by Prof. C. F. Burgess. The success of the production of pure metals free from aluminium, by means of aluminium as reducing agent, is due to Dr. Hans Goldschmidt, who employs the aluminium in powdered form. The success depends upon the attainment of so high a temperature that the reaction takes place completely and that the products are perfectly fluid.

If iron is to be reduced from iron oxide by means of aluminium, the energy required for the reduction of the iron is so small compared with the heat developed by the oxidation of aluminium, that the iron is obtained in form of a highly overheated steel, suitable for welding and repairing purposes. In a similar way Dr. Goldschmidt has produced a long series of carbon-free metals.

However, for the reduction of the oxides of titanium and tungsten to the metals the required high temperature cannot be obtained in this way, although their alloys with iron can be made. The addition of the oxide of iron to the charge supplies the heat necessary for complete reduction and for the agglomeration of the resulting iron alloy.

In order to produce pure titanium and tungsten, the author combines the Goldschmidt method with electric arc heating. He has found that Goldschmidt charges can, by a slight change, be fired with safety in an electric furnace of the arc type. Powdered fluorspar, or cryolite, is added to the charge to reduce the velocity of reaction. Other inert powders can, no doubt, be substituted for these. The charge is placed in the cavity of a furnace with a magnesite lining, the cover put on, and an arc started just above the charge. The usual heating in the experiments of the author was for 5 minutes at 300 amps. and 70 volts, followed by 5 minutes more at 600 amps. and 80 volts. About fifty reductions were made by this method. The reaction was occasionally vigorous, but never explosive, although 350 grams of powdered aluminium were used in some cases. The metallic oxides used were those of iron, nickel, cobalt, chromium, manganese, molybdenum, titanium and tungsten. The amount of retarder was diminished in case of the less readily reducible oxides. In a few cases the reaction could have been brought about by the usual method of an igniter, but owing to the presence of the silica, boric anhydride, or both, most of the charges required the heat supplied by the electric arc to complete the reaction.

The paper was briefly discussed by Drs. Bancroft, Burgess and Richards.

Electric Steel Furnace.

A paper by Mr. Gustave Gin on his new process for the electric manufacture of steel was read, in the absence of the author, by Dr. J. W. Richards. The construction of the furnace may best be seen from the plan shown in Fig. 1. It comprises essentially: First, a crucible (1) for fusion and refining by oxidation (corresponding to the pig end in open-hearth practice); second, a compartment (2) for the reduction of oxide of iron and recarburization; third, a chamber (3) for the color test, to get the proper carbon test.

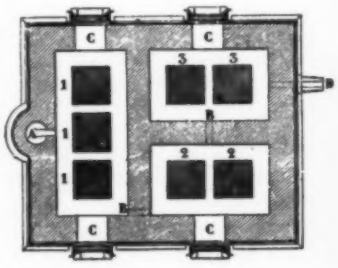

FIG. 1.—GIN STEEL FURNACE.

The electrodes of the compartment (1) are connected to one of the terminals from the source of electricity, and the electrodes of compartments (2 and 3) are both connected with the other terminal. The current passes from the electrodes to the metal through a layer of slag, which is the principal seat of the heating action of the current. The baths of metal communicate by openings B of sufficiently reduced section, in order that by reason of the Joule effect the metal may not remain solid.

To put the furnace into operation, melted iron or liquid steel is introduced through the orifice (A). It distributes itself

through the three compartments on the floors of which scrap iron is strewn, the pieces being placed in connection with (B). Then arcs are created, and little by little the material is introduced.

The oxidizing slag of compartment (1) is composed of some mineral or slag rich in oxide of iron, in addition some lime if the metal to be refined is phosphatic. The slags of compartments (2 and 3) are neutral and little reducible by carbon.

Aluminates of lime and magnesia, made from a mixture of bauxite, with limestone or dolomite, give favorable results. The addition of calcium fluoride makes it more fusible and mobile.

By means of the method of circulation adopted, the refined metal in (1) passes next into compartment (2), where the reduction of the dissolved ferrous oxide and the recarburization of the metal takes place.

The author makes the point that the electrodes can be raised or lowered at will, and that this is important when the metal is tapped.

The paper brought forth considerable discussion, in which Messrs. J. W. Richards, W. D. Bancroft, C. J. Russell, W. Smith, S. S. Sadtler, A. G. Betts, C. F. Burgess, E. F. Roeber and B. MacNutt participated. The general opinion expressed was that Mr. Gin had apparently given up the fundamental idea of his former steel furnace, which resembled somewhat an incandescent lamp filament in greatly magnified proportions. He has now adopted the use of a slag in which the electrodes dip. This arrangement has proven very successful in the furnace of Heroult. Dr. Richards pointed out that Heroult is here evidently on sound ground, since with a very high temperature of his furnace he can employ more refractory slags, and can produce reactions which are impossible in an open-hearth furnace. He can thus very effectually remove sulphur and phosphorus.

It was doubted by various speakers whether the Gin furnace has ever been tried in practice, since its construction would involve various difficulties in operation. It has a large radiating surface. There will be some difficulty in keeping the contents of the three compartments separate. The design of the Gin furnace also seems to violate the metallurgical principle that one should not try to carry out essentially different processes in the same apparatus.

In the discussion it was also brought out that the first commercial application of the electric furnace for the manufacture of steel in the United States will be at the plant of the Halcomb Steel Co., of Syracuse, N. Y., the plant being for the production of 80 tons per day. The Heroult furnace will be used there.

Dr. Leonard Waldo then presented what was essentially a new paper, giving very interesting information on the development of the electric induction furnace in this country by Colby and Waldo, and in Sweden by Kjellin. Dr. Waldo pointed out that in electrothermic processes very heavy electric currents must be handled, and this involves considerable difficulties. In all of the old electrometallurgy it has been necessary to deliver current through electrodes; in this case the management of the electrode becomes extremely difficult. At some time or other the current through the electrode either passes through a mixed charge with varying resistance or makes an imperfect contact. When that happens, the current arcs; and when it arcs there is the practically uncontrollable temperature of 3850° C., and there results a corresponding impurity and a corresponding difficulty and a corresponding intense action at the single point of the arc. This is the reason why a furnace without electrodes suggested itself. Mr. Edward Colby built the first induction furnace in this country, and almost contemporaneously the engineering firm of Sprague, Duncan & Hutchinson independently experimented with one of their own construction; but, unfortunately, at that time the problem of the alternating-current dynamo and of the transformer were by no means in that shape as they are to-day. When Kjellin began later his work in Sweden he had the advantage of finding these alternating-current engineering problems solved.

Dr. Waldo then sketched the principle of the induction furnace as the special case of a transformer with a single secondary winding (the molten bath). It represents the ideal condition in metallurgy. Here we have the containing crucible with no electrodes; no contact with fuel in any shape; the efficiency is high; the melting takes place at any rate desired. This control of the rate of heating is a most important advantage. Everybody knows how long it takes after a crucible reaches a white heat before the final complete fusion takes place. The induction furnace permits adding quickly the energy units which make final minutes in the melt take the place of almost hours, when the high temperature is causing costly radiation and racking the mechanical stabiltiy of crucibles and furnace construction alike. At high temperatures approaching the melting point, it is possible to push the rate of temperature increase to 1° C. per minute, by adding 2 kw for every 100 pounds of steel; or to put it practically, the steel is raised the last 200° C. by adding 40 kw for 10 minutes.

If the furnace chamber is built of the proper material, its life is indefinite, since the heat is generated wholly within this chamber and not in excess of the fusion requirements. Dr. Waldo indicated the efficiency of the best induction furnaces by stating that they melt 1 ton of steel with an energy consumption of 500 kw-hours. Of course, in this type of furnace the coal efficiency rises very much over the coal efficiency in the crucible process.

Dr. Waldo spoke in a very interesting and humorous way on some observations peculiar to the operation of an induction furnace. The temperature in the metallic bath follows almost instantaneously any change of the energy supply in the primary circuit, apparently without any time lag. If the charge is made up of a series of steel rings to be melted, then when the furnace is started the rings will rise as though they wanted to get out of the furnace, and the furnace begins to sing, often with a beautiful, clear note, and the workingmen begin to look for their overalls and see what the chances of escape are.

Dr. Waldo remarked that a complete theory of the induction furnace and of the special features which distinguish it from the ordinary transformer would be very valuable.

Refining Silver.

A paper by Mr. Anson G. Betts on his electrolytic process for refining silver was then presented. As was already mentioned in Mr. Betts' article on page 145 of our April issue, the feature of the process consists in using salts of strong non-oxidizing acids, forming soluble silver salts. Dithionic acid gives fairly good results, but the best results are obtained with methyl—sulphuric acid. An interesting new feature mentioned in Mr. Betts' paper is that a small addition of carbon disulphide improves the quality of the deposit; otherwise the process, as described, is the same as mentioned in our April issue.

Parting of Bullion.

An interesting paper by Mr. F. D. Easterbrooks, of the Raritan Copper Works, of Perth Amboy, N. J., discussed the question of electrolytic versus sulphuric parting of bullion.

With the sulphuric acid method refined gold can be produced, ready for shipment, 24 to 30 hours after placing the bullion in the kettles, which is several days earlier than is possible with an electrolytic method. This is advantageous in those cases where the ore is high grade and interest charges have to be considered. A daily cut-off of the gold treated can be made, and thus a quick check obtained of output on input. There is also almost no silver tied up in plant, as in the electrolyte and cathodes of an electrolytic process.

The acid solution from the reducing tank containing the copper used to reduce the silver sulphate solution is disposed of in either of two ways: the bluestone crystallized on lead strips

and the mother liquor concentrated and used again in the kettles, or, as is the case in copper refineries, added directly to the electrolyte, in which case the value of the acid added per ounce of silver parted, after deducting the power cost of depositing the copper in insoluble anode tanks, determines the amount at which an electrolytic parting process must operate below the sulphuric in order not to exceed the costs of the latter, since with an electrolytic parting process sulphuric acid must be bought especially for the copper electrolyte.

There is a loss of acid at the kettles while dissolving silver in sulphuric acid. This loss depends partly upon the rate at which the process is conducted and on the efficiency of the condensing apparatus, but in any case amounts to a considerable percentage of the amount used.

Another objection to the acid method is the non-elimination of tellurium from the silver during parting. This element materially affects the physical properties of the silver with which it is alloyed, small quantities causing it to crack at the edges while being rolled.

In minting operations the fine silver is first alloyed with 10 per cent copper. One part per thousand of tellurium in the silver will cause this alloy to crack when rolled out, so that five-tenths to six-tenths part per thousand (.05 to .06 per cent) is the probable safe maximum amount of tellurium that can be present in silver and meet the strictest requirements. To produce silver from material containing much tellurium, so that the refined product will not contain more than the above maximum allowable amount, requires, when parting with sulphuric acid, an exposure of the bullion in the cupel to air and nitre for a considerable length of time. This is shown by the following illustration.

The usual quantity of slimes were melted in a cupel furnace. After skimming the slags, two tuyere pipes 2 inches in diameter were placed so that air under 5-ounce pressure blew directly on the surface of the bullion. Nitre was used freely. Twelve and one-half hours were required to eliminate sufficient tellurium to secure a refined product of the requisite fineness. The analysis of the several samples are given in Table I., which shows also the early removal of the selenium.

This bullion, represented by sample E, was parted with sulphuric acid, and the refined silver contained .6 part of tellurium. A portion of the same lot parted electrolytically contained not a trace.

TABLE I.—ELIMINATION OF TELLURIUM AND SELENIUM. CHARGE NO. 89.

	Time Taken.		Parts Fineness.			
			Te.	Se.	Ag.	Au.
Sample A	April 8,	5.00 A.M. . . .	34.30	13.45	903.72	15.98
" B	"	9.00 A.M. . . .	23.40	.81	939.47	16.53
" C	"	1.00 P.M. . . .	5.36		968.61	17.19
" D	"	3.00 P.M. . . .	2.41		973.35	17.25
" E	"	5.30 P.M. . . .	1.31		973.46	17.04

With electrolytic parting we have a choice of two distinct systems of depositing silver on the cathode, one in a loose crystalline form at a relatively high-current density, as in the Balbach and Moebius methods, the other with the aid of gelatine in an adherent form at a lower current density.

The electrolyte used is a copper-silver nitrate solution, although recently Betts has proposed using a silver methyl-sulphate solution.

These methods all have in common the characteristic of parting and refining bullion free from gold and tellurium at one operation, the deposited silver being melted and poured into bars without any further refining, as in the sulphuric acid process. Silver placed in the tanks as anodes is not handled until taken out as refined silver, whereas in the acid method the silver either in solution or as cement must be transferred several times with the aid of siphons, steam, etc., before it is in a condition to be melted. For these reasons it is possible to operate an electrolytic parting plant with a higher degree of neatness and cleanliness (such as the value of the material treated requires) than is possible with acid parting.

A parting plant using the Balbach method is simple in construction and operation. Fig. 2 shows the cross-section of a tank. The cathode is made of ½-inch Acheson graphite slabs fitted to the bottom. Two silver contact pieces rest respectively on the bullion to be parted and the graphite slabs. Bullion cast in thin, square slabs is contained in a cloth case, which is supported on a wooden frame suspended over the tank. The gold slimes accumulate on the under side of the bullion, between it and the cathode, increasing the resistance as the operation continues. Each tank has a cathode surface of 8 square feet and a current density of 20 to 25 amps. per square foot is used. The voltage averages 3.8 per tank, and an average ampere efficiency of 93 per cent was obtained on a continued run, while occasionally an efficiency of 98 per cent was secured. The power required is 31.5 watt-hours per ounce of fine silver produced.

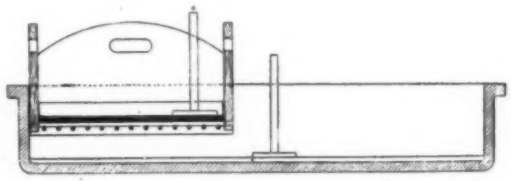

FIG. 2.—BALBACH TANK.

Most of the silver is deposited on the cathode surface directly under the anode, and the reduction of the distance between anode and cathode is limited by the space necessary to reach in and remove it, which has to be done frequently on account of the silver bridging across to the cathode. This serves also to agitate the electrolyte. There is gassing in this tank, and the consumption of nitric acid is much higher than in the Moebius method.

At 20 amps. per square foot about 32 per cent of the daily output of each tank is held permanently in stock in electrolyte and contacts, which is less than is retained in the Moebius method.

In Fig. 3 is shown the cross-section of a Moebius tank. They are arranged in units of six, placed end to end, each unit being provided with apparatus for raising the boxes containing the deposited silver together with the anodes and cathodes, and with arrangements for imparting a reciprocating motion to the wooden scrapers. There is no system of circulating the electrolyte, but the scrapers moving back and forth agitate it. The anodes are contained in a cloth frame which holds the gold slimes, and the silver is brushed off from the silver cathodes by the wooden scrapers, and drops into a box with hinged bottom. It is removed by raising the boxes above the top of the tanks and emptying it into a tray placed beneath. This operation requires one-half hour per day per unit. Each tank has a cathode surface of about 16.5 square feet, and a current density of 20 to 25 amps. per square foot is used. The voltage between electrodes is 1.4 to 1.5, and the power cost is 13.2 watt-hours per ounce of silver deposited. An average ampere efficiency of 94 per cent is obtained. At 20 amps. per square foot 41 per cent of the daily output of each unit is permanently held in stock in cathodes and electrolyte.

The necessity of cutting out of service the units of a plant using the Moebius method to remove the silver, and the frequent siphoning off and replacing of portions of the electrolyte in each tank in both the Balbach and Moebius methods, to maintain it of fixed compositions, are objections overcome by depositing the silver on the cathode in an adherent form.

This method permits of an arrangement of tanks and elec-

trodes and a system of circulation of electrolyte similar to that used in the multiple system of copper refining.

The finely divided condition of the gold in the bullion, which in commercial work rarely contains more than forty parts per thousand, requires that the anodes be inclosed in a cloth frame to keep the deposited silver free from gold, as the light, fine particles do not fall to the bottom of the tank with sufficient rapidity. A current density of 10 amps. per square foot is used, and the power cost is nearly identical with the Moebius method; 28 to 32 per cent of the daily output is retained in cathodes and electrolyte.

Gold from either the sulphuric or electrolytic parting process can easily be produced of a fineness of .990 or above, free from silver. The government charge for melting and assaying such gold is so low, varying from .6 to .9 cents per ounce, depending on the weight of the bar, that there seems to be no immediate possibility of an electrolytic gold-refining process, such as the Wohlwill, becoming an attractive commercial proposition, except in those cases where platinum is present and the output large. Such a process would increase costs by delaying shipments, with loss of interest on gold in process, and that permanently held in stock in cathodes and electrolyte, and by increasing labor costs with no increase in the value received for the gold.

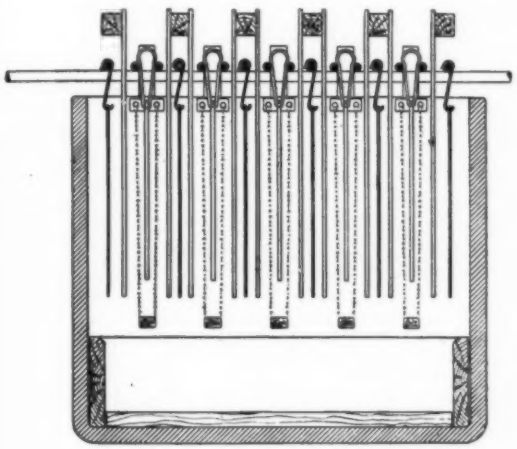

FIG. 3.—MOEBIUS TANK.

The paper was briefly discussed by Messrs. Betts, Sadtler and Bancroft.

INSULATING PAINTS.

An interesting paper was then presented by Dr. MAXIMILIAN TOCH, who pointed out that electric traction is responsible for a new chemical industry, that of insulating paints. Traction engineers as well as municipal authorities discovered that an old steel bridge, over which a new trolley line passes, soon shows the effects of the decomposition of the steel, and this deterioration is now called electrolysis. A road which is run by the third-rail system soon shows evidence of oxidation in spots hitherto unnoticed. Against these ravages insulating paints, compounds and varnishes are used, and while many of these materials are excellent when they are first applied, they become useless in proportion to the conditions to which thy are subjected.

Dr. Toch pointed out that this subject is really so vast that he could only touch on the topic in a general way. An important point is the recognition of the fact that materials which are designed for a tunnel are useless in the sunshine. The materials used in tunnel work must withstand moisture, and unless they do they will be disintegrated until eventually they form conductors. As a rule, the paints for tunnel or underground work are composed of bitumens, and are black. The bitumens as a class are of the polymethylene group, and their structure is one atom of carbon and two of hydrogen, combined many times. Moisture will neither add to nor subtract from this structure. On the other hand, there are the fatty acid oils which form the bases of many good insulating paints, and when these are used in damp places they are not split up but added to, and their value as an insulating paint is lessened.

While bitumens are good for tunnel work, a study of the behavior shows that sunlight destroys them, and the two atoms of hydrogen combine with oxygen to form water, while carbon is set free. Consequently, it is noticed that a bitumen insulating varnish in sunshine soon becomes smutty, due to the liberation of carbon, and this justifies the deduction that for exposed use bitumen is not to be relied on, excepting where it can be replaced every few months.

If we take sugar and add to it strong sulphuric acid, a reaction takes place which demonstrates that sugar is composed of carbon and water, and inasmuch as sulphuric acid has a great affinity for water, the reaction is complete. This experiment was shown by Dr. Toch, who pointed out that many of the bitumens and waxes are acted on by acid in this manner. Since we have 14 per cent hot acid solutions to deal with in the electrolytic deposition of copper, it is most interesting to observe the action of the acid on the various electrolytes, and those that appear best in the beginning are often the soonest to fail.

The time of drying is often a factor in the life of an insulating paint. The slow-drying paints should never be subjected to aqueous liquids until drying is complete.

For cross-arm painting a very high resistance is not so essential as one that will withstand the weather, and a liquid medium which soaks into the pores of the wood is better than one which dries by oxidation and forms a film which peels.

Concerning third rails, the author pointed out that they are subject to oxidation in so violent a manner that it is often found necessary to replace them sooner than the running rails. The sides or web of the rail can be protected with a paint which will resist corrosion and short circuiting. The top is sometimes covered with a wooden guard. This guard must be painted with a fire-resisting and insulating material.

Concerning return wires, Dr. Toch pointed out that it is remarkable how corrosion takes place along the same. As a matter of fact, the metal surrounding these places is usually coated with an oil paint containing lead and zinc, and it has taken practical demonstrations to convince some mechanics that such paints produce, or superinduce, electrolytic corrosion. Strict vigilance and copious applications of the correct material are necessary in such places.

In the conclusion of his paper, Dr. Toch recommended to professors of electrochemistry to take up this subject with their students and allow them to work out for their thesis subjects of this kind. There is no reason why a third-rail paint should not be made one that will stand both dampness and sunshine for a year. There is also no reason why insulating materials should not serve as protector to metals against oxidation as well as electric currents. Fortunately, we have records of the preservative action of many paints on wood and metal, and it only remains now to work out the proper combination, and to this end chemists who have a technical training ought to be employed by colleges to give students occasional lectures on raw materials, so that they obtain a fundamental training in the theory of coatings. A student who knows these things has a better future in store for him and an easier chance for employment.

Dr. Toch stated that very extended research work in his own laboratory has established the fact that from the way a paint is made up it is possible to predict what it will do.

A peculiar observation made on the New York subway as well as on the elevated road is that the steel connected to the

negative side of the electric system (hence forming the cathode) shows greater corrosion than the positive side, although corrosion is observed on both sides.

This last point was the subject of some lively discussion by Messrs. Bancroft, Hering, Larchar, Richards and Sadtler, who suggested various explanations.

Dr. Toch stated that there are three different kinds of rust. Electrolytic rust is a mixture of Fe_2O_3, $2H_2O$ and Fe_2O_4 $1H_2O$.

Active Oxygen, Electrically and Chemically Produced.

An interesting paper by Dr. Richard von Foregger, of the Roessler & Hasslacher Co., was then presented. The author discussed the utilization of active oxygen for sterilizing, bleaching, metallurgical and other purposes, produced from the series of peroxides which are now being made by the Niagara Electrochemical Co. (as was already mentioned in a paper of Mr. Fitzgerald, page 255 of our July issue).

There are two kinds of autoxidizers which are direct sources of active oxygen; one is ozone, the other is represented by these peroxides, chiefly of the alkaline and earth alkaline metals. In their decomposition, *i. e.*, in their formation of active oxygen, the action is that ozone is split up into O_2 and active oxygen, while the dioxides are split up into lower oxides and active oxygen.

These two sources of active oxygen, compared from a practical side, show ozone as a gas and the dioxides (with the exception of hydrogen peroxide) as a powder. Ozone gas has to be produced at the place of consumption by electrical energy. It is an unstable gas which cannot, for practical purposes, be stored, and has to be utilized immediately after its formation. On the other hand, the peroxides are stable, transportable, storable and enter automatically into reaction whenever required with a fixed amount of energy.

Oxygen is a vital part of life, and organic life has been described as a slow process of oxidation. Besides this, oxygen has in nature three main features, which in proper reproduction will become indispensable factors in industrial work. Oxygen disinfects, it purifies and it bleaches.

Dr. von Foregger discussed at some length the sterilization of water, and gave some data on the use of ozone as produced by silent electric discharge. He then compared this with the use of active oxygen obtained from peroxides.

"Assuming that we have a 65 per cent calcium peroxide, *i. e.*, a preparation containing 65 per cent dioxide (CaO_2)—the rest being monoxide or oxyhydrate—corresponding to 15 per cent of active oxygen, and assuming that the cost of 1 kg calcium peroxide is $2, we find that 1 kg contains 150 grams available oxygen, and, therefore, the cost of 1 kg active oxygen is $12.50.

"Taking the figures of Siemens & Halske of 0.67 grams active O per m^3 water as a basis, we find that the cost per m^3 water sterilized by means of calcium peroxide is 0.84 cents. Allowing the high addition of 20 per cent for operating expenses and amortization of the little machinery that is required, we obtain a total cost of 1 cent per m^3 sterilized water."

"To be just, it must be said that this total cost occurring with calcium peroxide will not be reduced further than to a certain limit above 0.84 cents, even if the operation takes place on the largest scale, as in this event the calcium peroxide counts almost as exclusive expense. On the other hand, for the same reason, the total cost can hardly surpass 1 cent per m^3, even if the operation is done on a very small scale."

Compared with ozone processes, the cost of using calcium peroxide is slightly higher for large plants. But it is for smaller plants that the use of calcium peroxide offers advantages in cost. It also has the great advantage of simplicity, there being practically no machinery required. A tank fitted with a stirring apparatus and eventually, but not absolutely necessary, a filter and one man to handle it, is all that is required.

The calcium peroxide is applied in powdered form as it comes from the manufacturer, and an equivalent of sulphuric acid, or an organic acid, forming an insoluble calcium salt, as, for instance, citric acid, is added to hasten the liberation of active oxygen and to precipitate the calcium. The bactericidal action is complete in the time from 5 to 30 minutes, and the resultant water is just as pure and good as could be.

With respect to the time required for the peroxide process this is much less than by the use of ozonized air. In the latter case there is only a limited amount of ozone available per unit or time and unit of space.

The main value of the peroxide method consists, however, in its use outside the sterilization plant and without the aid of any apparatus. In form of calcium peroxide, or magnesium peroxide, we are able to "carry available oxygen around in our pockets ready for sterilization of our drinking water at any place." Some details are given on very satisfactory results of bacteriological tests of the effect of this treatment of water.

Dr. von Foregger briefly referred to the sterilization and preservation of food by means of ozone or peroxides, and then passed over to the subject of bleaching. The success with which sodium peroxide has been introduced in this country as well as in Europe for bleaching textile and fiber and straw, is believed to vouch for its commercial adaptability. The author stated that perborate (one other material of the series) is becoming extensively used in Germany for bleaching olive, cotton and linseed oils, and thinks the cost is 1.06 cent per kilogram of oil. In a series of experiments which he made with cotton-seed oil, as a substitute for olive oil, he used calcium peroxide, and found that ⅛ per cent of this material furnished satisfactory results as to shade of bleach, and that in taste and flavor the oil was rather improved and by no means hurt. He figures that the cost of this process will be about ¼ cent per kilogram of oil.

Dr. von Foregger then turned to a discussion of the use of active oxygen in gold metallurgy.

He referred to the controversy between McArthur, the inventor of the cyanide process for extracting gold, and Elsner. "McArthur bases the reaction occurring in the cyanide process upon the following principle:

$$2Au + 4KCN + 2H_2O = 2KAu(CN)_2 + 2KOH + H_2$$

He always pretended, and still pretends, that the presence of oxygen during the process is of no value whatever. Elsner, McLaurin and Gogder, on the other hand, pretend that the presence of oxygen is essential, and describe the reaction as follows:

$$4Au + 8KCN + 2H_2O + O_2 = 4KAu(CN)_2 + 4KOH$$

"Since publication of the results of investigations made by Bodländer (*Zeitschr. f. Angew. Chem.*, 1896, p. 583), it can be said that this question is cleared. He proved that in the reaction the amount of oxygen which is put into activity is nearly the same as the amount of oxygen which combines (about 72 per cent). With the theory of dissociation on hand he then came to the following reaction:

$$\overset{+}{2Au} + \overset{-}{4K} + \overset{-}{4CN} + \overset{+}{2OH} + \overset{+}{2H} + O_2 =$$

$$= \overset{-}{2Au(CN)_2} + \overset{+}{4K} + \overset{-}{2OH} + H_2O_2$$

"Gold, during its solution in potassium cyanide, at the presence of air or oxygen is then a pseudoautoxidator, *i. e.*, it produces first the secondary autoxidator K or H, and K or H produce the autoxidation forming potassium peroxide hydrate or hydrogen peroxide. The secondary process then of the solution of gold may be expressed as follows (see Engler and Weissberg: Autoxidation):

$$2Au + 4KCN + H_2O_2 = 2KOH + 2KAu(CN)_2$$

"The more peroxide formed—dependent on the presence of oxygen—the quicker the solution of gold. Gold-mining experts may have come to this result by practical experience, despite the contradictory assertions of McArthur. It is probably due

to this fact that considerable quantities of sodium peroxide are being used by gold-extracting concerns. Of late, sodium perborate has attracted the attention of that part of mining experts, as borax, which besides peroxide of hydrogen is formed in the solution of perborate, seems to be a suitable medium.

"A practical confirmation of the theory of the value of oxygen in the cyanide process is found in the so-called double treatment, consisting in the use of two vats, the contents of one vat after having undergone a treatment being discharged into the second vat for renewed treatment, during which proceeding the material is exposed to the air, drawing its advantage in oxygen supply.

"The importance of oxygen is fully recognized in the refinement of gold bullion and cyanide precipitates. Kirke Rose (*Inst. of Mining and Metallurgy*, April 13, 1905) concludes after a series of elaborate experiments that "base metals can be removed from gold and silver bullion by means of a current of oxygen passed through them." Rose in his experiments used air as well as oxygen gas, and found that air can do what oxygen does, only more slowly and without such intense action, and that it is obviously a cheaper oxidizing agent than oxygen in any other form."

Dr. von Foregger then referred to some tests made at the laboratory of Borchers, on Aachen, on the use of oxygen in the copper converter process. These experiments proved that in using blast air containing 5 per cent to 9 per cent above the normal contents of oxygen, first, the temperature was remarkably raised, and, second, the time of blasting was considerably shortened, viz.: to two-thirds and one-half of the time needed with ordinary blast air.

The author finally discussed and demonstrated "oxone" which is fused peroxide of sodium, prepared to generate oxygen gas instantaneously, upon being immersed in water. "While sodium peroxide in its powder form dissolves in water, forming peroxide hydrate or atomic oxygen, not entering the gaseous state, the fused peroxide by heat of dissociation in the instant of solution drives out all its available oxygen. That this oxygen, which is in the molecular form, does contain a certain percentage of ozone, it is fair to assume."

It is found that 1 pound of oxone furnishes on an average 2.15 cubic feet oxygen gas. As oxone has a small volume, the gas production amounts to 312 times its own volume, or 130 times the volume of water.

Oxone is adaptable for shipment to any distance and offers no danger of explosion or combustion, and no inconvenience whatever in the use except the strong causticity, which has to be taken into consideration when handling the same.

The paper elicited considerable discussion. Dr. Toch thought that the new peroxides seemed a good thing, and might fill a want for bleaching linseed oil, making the same siccative, etc. Dr. Doremus referred to the possibility of using calcium permanganate or potassium permanganate. Dr. Richards spoke of the use of sodium perborate in connection with refining gold and silver. Mr. Fahrig thought that for the extraction of gold and silver from ores, condensed active oxygen is not so much required as a large surface of oxidizing air. Dr. Doremus compared the cost of using peroxides for making oxygen in large quantities with that of using compressed oxygen gas. From the discussion it appeared that the production from peroxides is even somewhat cheaper, but Dr. von Foregger pointed out that these peroxides are really expected to prove useful rather for generating oxygen in situ, so as to produce certain sterilizing, bleaching, etc., reactions, than for the manufacture of large quantities of oxygen gas. He also referred to the following valuable property of oxone: When dissolved in water, oxygen is evolved, while simultaneously the sodium hydrate, formed on the decomposition of the sodium peroxide, absorbs carbon dioxide. This property of simultaneously producing oxygen and absorbing carbon dioxide is of importance for use in submarine boats, in mines, etc.

Arsenic in Pickling Solutions.

A paper on this subject was presented by Prof. Charles F. Burgess. It has been known for some time that the sulphuric acid pickle, which exerts a vigorous dissolving action upon an iron or steel surface, may be rendered almost completely inert by the addition of a small amount of arsenic. In the tests made by the author a five-normal solution of sulphuric acid was used, and to a portion of this solution was added a small quantity (a small part of 1 per cent) of arsenic in the form of As_2O_3. To determine quantitatively the influence of the pure and the arsenic-containing solutions, strips of spring steel were subjected to their action, and the dissolving and the weakening of the steel was measured.

It was found that in 1 hour's time the amount of iron dissolved by the arsenic-free solution was about thirty-four times that dissolved by the impure solution; also that during the first 20 minutes the ratio between the action of the two solutions was 9.1 to 1, and during the last 40 minutes the ratio increased to 94 to 1, showing that the protective action of the arsenic increases with the time. In the pure solution the rate of corrosion increases, as shown by the fact that over four times as much iron was dissolved during the last 40 minutes as during the first 20; while with the arsenic-containing solution the rate of solution materially decreased. It was also noted that when first immersing the steel in the impure solution hydrogen was given off, but this evolution quickly diminished, and at the end of 1 hour the evolution of hydrogen had ceased, while in the pure acid the evolution of this gas was vigorous.

While arsenic is harmful as an addition to an acid pickle, the same phenomenon may, of course, also be applied to retard the action of acid on steel when no such action is wanted. On account of this strong action of acid solutions of steel, certain classes of steel articles, such as steel piano wire, clock springs, measuring tapes and the like, cannot be pickled, and it is claimed by some that they cannot be nickel-plated without damage. In this connection the effect of arsenic may be put to good advantage. By means of a special machine, which enabled him to test the brittleness of a strip of steel, Prof. Burgess showed that arsenic exerts a marked influence in diminishing the rotting effect of the sulphuric acid solution. A solution of hydrochloric acid having a corresponding strength was also tested, and it was found that while the presence of arsenic in it exerts an influence similar to that exerted in sulphuric acid, its influence is not as pronounced.

It is generally recognized that the nickel-plating process, as usually operated, has a decided weakening effect on thin steel springs and the like, and the supposition is justified that it is the pickling part of the process that is largely responsible for the trouble. If a steel spring is pickled in an arsenic-containing pickle, and subsequently nickel-plated, it is found to be stronger than when pickled in pure acid before plating.

Prof. Burgess urges to carry out further experimental researches on the quantitative effect of arsenic and to determine the underlying cause of this effect.

The paper was briefly discussed by various speakers, who offered one or the other possible explanation of the influence of arsenic.

Electrochemical Card Index.

Mr. C. F. Carrier, Jr., gave a brief and interesting account of the thorough work being done by Mr. A. Voege and the Concilium Bibliographicum, in Zurich, in connection with the preparation of a complete card index relating to articles, patents, etc., on electrochemical subjects. Practically all periodicals of the world are to be covered. Prof. Bancroft made some complimentary remarks on this work, and Dr. Waldo emphasized that it is absolutely necessary to use exactly the "standard" size of card.

For details concerning the undertaking the reader may be referred to two papers by Mr. Voege, published on page 313 of our Vol. II., and page 107 of our Vol. III.

Electric Zinc Smelting.

A paper by Prof. Oliver W. Brown and W. F. Oesterle was then presented, in the absence of the authors, by Mr. S. S. Sadtler. In the introduction the authors referred to the present zinc distillation process as the most wasteful metallurgical operation used industrially at the present time. The fuel consumption, the cost of repairs and the loss of zinc are very large. The average life of the retorts used in many works is only 40 to 50 days; while the loss of zinc is seldom less than 10 per cent, and sometimes more than 25 per cent of the zinc in the ore.

Another great drawback to the process is that the retorts will hold only about 65 pounds of ore. The zinc retorts most commonly used are fire-clay tubes about 4 feet 2 inches long, 8 inches in diameter and 1¼ inches thick. They are made closed at one end, and into the mouth of each retort is fitted a fire-clay condenser. They are supported at each end by projections from the walls of the furnace; and are placed in horizontal rows in the furnace in such a manner that the flames entirely surround them while they are being heated.

The authors then briefly described the operation of the present zinc distillation process, and pointed out its inherent drawbacks. Electrochemists have attacked the zinc problem along three different lines. The first is the conversion of the zinc in the ore into a salt soluble in water, and the subsequent electrolytic precipitation of the metal from an aqueous solution. Of such processes that of Hoepfner is the only one which appears to have approached a commercial success. Brunner & Mond have during the last few years turned out a very pure electrolytic zinc from their works at Wilmington, near Chester, England. (See Meyer, our Vol. III., page 9.)

A second line of research relates to electrolysis of a fused salt of zinc. In this field the Swinburne-Ashcroft process "seems to have a very bright future." (See our Vol. I., page 412, also Vol. II., page 404.)

The third line of endeavor has been the smelting of zinc ores in the electric furnace. The Cowles Brothers, C. Casorette and F. Berboni (Brit. patent 472, May 19, 1900), De Laval (see our Vol. I., page 425; Vol. II., page 423; Vol. III., pages 54 and 209) have designed electric furnaces in which roasted ores are smelted in the ordinary manner except that the heat is generated by electrical means.

A Dorsemagen has tried to produce simultaneously zinc and carborundum from zinc silicate ores according to the reaction $Zn_2SiO_4 + 5C = 2Zn + SiC + 4CO$.

Dankwart (U. S. patent 746,798, Dec. 15, 1903) has devised a process in which he smelts mixed sulphide ores containing zinc, with lime, coke and sodium sulphate. He mixes the different materials in such proportions that the sulphur of the ore is converted into alkaline and alkaline earth sulphides, while the zinc is liberated as vapor and is condensed in the usual manner.

This is similar to a process of Kirkpatrick-Picard (U. S. patent 692,148, Jan 28, 1902), except that the latter does not use sodium sulphate. Kirkpatrick-Picard's process is represented by the following reactions:

$$ZnS + CaO + C = Zn + CaS + CO$$
$$PbS + CaO + C = Pb + CaS + CO$$

$$4ZnS + 2Fe_2O_3 + 6C = 4Zn + 4FeS + 6CO$$
$$4PbS + 2Fe_2O_3 + 6C = 4Pb + 4FeS + 6CO$$

He forms the mixture into briquets before the distillation.

The authors of the present papers, Brown and Oesterle (our Vol. II., page 32) have worked in the laboratory of the University of Indiana and have devised a process based on the electrical smelting of changes of unroasted zinc blende, lime and carbon, mixed in proportions corresponding to the following equations:

$$(a)\quad 2ZnS + 2CaO + 7C = 2Zn + 2CaC_2 + CS_2 + 2CO$$
$$(b)\quad 2ZnS + CaO + 4C = 2Zn + CaC_2 + CS_2 + CO$$

The authors first tried the reduction of a charge containing equal molecular weights of zinc blende (59.6 per cent zinc in ore) lime and carbon (coke) in an enclosed electric resistance furnace lined with firebrick. This the same charge as that used by Kirkpatrick-Picard. When this charge was heated in the electric furnace the ore was readily reduced, the metallic zinc distilled out and a portion of it condensed in an iron tube which served as condenser. The material remaining in the furnace after the distillation, consisting of impure fused calcium sulphide, contained only 0.13 per cent of metallic zinc.

They next made a study of the electric reduction of charges of zinc blende, lime and carbon (coal or coke), mixed in proportions corresponding to the equations (*a*) and (*b*) given above.

When a charge containing 194 grams of zinc blende (59.6 per cent zinc), 112 grams of lime and 84 grams of coke was heated in an enclosed firebrick-lined electric resistance furnace, with a current of 50 amps. at 30 volts for 2 hours, zinc distilled and condensed, and the impure carbide remaining in the furnace contained only 0.036 per cent of metallic zinc and 2.89 per cent of sulphur. The other impurities in the carbide naturally depend on the purity of the ore treated.

When working with the very small furnace required to smelt charges containing only 194 grams of ore, it was not deemed desirable to endeavor to condense the largest possible proportion of the distilled zinc in a solid metallic form. As experience has shown, the difficulties in condensing the zinc as liquid metal, instead of zinc dust, disappear as the size of the furnace is increased.

The analyses of gases coming from the furnace during the operation, of the materials in the furnace after smelting, etc., show that the changes which take place in the smelting are probably best represented by equations (*a*) and (*b*).

Some additional experiments which were carried out during 1903 and 1904 by Prof. Brown in Prof. Burgess' laboratory at the University of Wisconsin, on the reduction of zinc blende, furnished the following results:

When the following charge: 3.98 kg zinc blende (containing 58.0 per cent of zinc), 2.24 kg lime (containing 38.2 per cent of magnesia), 0.84 kg of carbon (equal weights of coal and coke), was smelted in an enclosed electric resistance furnace, the material remaining in the furnace after the distillation contained only 0.10 per cent of metallic zinc. This experiment shows that even when a lime very high in magnesia is used, practically all of the zinc is reduced and distills out of the furnace. However, it is hardly necessary to remark that good calcium carbide cannot be made when a lime containing 38 per cent of magnesia is used.

The internal dimensions of the furnace in this experiment were: Length, 12.5 inches; depth, 8.5 inches, and width, 4.5 inches. The inner walls and bottom of the furnace were of magnesia brick. A layer of dry lime was placed on the outside of the magnesia brick, then a layer of firebrick, followed by another layer of lime, and finally the whole was encased in a sheet-iron jacket. A round Acheson graphite electrode, 2 inches in diameter, entered the furnace at each end. These electrodes were fastened firmly into plates of Acheson graphite 0.5 inch thick, which were placed vertically at each end of the furnace, and reached from the bottom to within 1.5 inches of the top. In order that the furnace should be gas tight, the portions of the graphite electrodes which passed through the walls of the furnace were packed in powdered magnesia brick.

The materials comprising the charge were passed through a twenty-mesh sieve and thoroughly mixed, before placing in the furnace.

Connection between the two end electrodes was made by two cores of broken carbons (broken to pieces about 0.5 to 1 inch), which were imbedded in the charge. The lower core of granular carbon was placed 2 inches from the bottom of the furnace, while the second core was about 4 inches above the lower core.

The charge was filled into the furnace to within 1.5 inches

of the roof, and was covered with a layer of broken pieces of coke. A carbon tube, 0.5 inches internal diameter and 12 inches long, penetrated the side wall of the furnace, about 2 inches from one end and 2 inches from the top. The tube passed nearly horizontally through the walls of the furnace, the outer end being about 0.5 inch lower than the inner. On the outer end of this carbon tube was fastened a short piece of 1.5-inch iron pipe, which was surrounded with asbestos, and served as condenser for the zinc. The outer end of the pipe was nearly closed with fire-clay. At intervals during the distillation of the zinc the fire-clay plug was removed, and the melted zinc, which had condensed, was allowed to flow out.

The furnace was closed at the top by an Acheson graphite plate, 0.5 inch thick. A layer of lime was placed over the graphite plate, and on this were placed three layers of fire-brick. When the furnace was sealed with dry powdered lime in this manner, it was quite tight, and very little gas escaped except through the condenser.

A current of about 172 amps. and 68 volts was passed through the furnace for 6 hours and 40 minutes. Zinc vapors had stopped coming from the furnace when the current was broken.

After the furnace was allowed to cool and the cover removed, it was found that the charge was a loose porous mass, which could nearly all be removed with the hands. The temperature had not been sufficient to fuse the charge, although all but 0.1 per cent of the zinc was expelled from the furnace.

In order to gain some idea of the temperature required to reduce and distill the zinc from various charges, and also the relative value of various charges, four different mixtures were made up and heated in a hot coke fire in a wind furnace.

The materials in each charge were pulverized to pass a twenty-mesh sieve and well mixed. The blende used contained 58.6 per cent of metallic zinc. The charges were as follows:

No. 1 contained zinc blende, 97; lime, 28, and coke, 24 grams, and corresponds to the equation,

$$2ZnS + CaO + 4C = 2Zn + CaC_2 + CS_2 + CO$$

No. 2 contained zinc blende, 97; lime, 56, and coke, 42 grams, and corresponds to the equation,

$$2ZnS + 2CaO + 7C = 2Zn + 2CaC_2 + CS_2 + 2CO$$

No. 3 contained zinc blende, 97; lime, 56, and coke, 12 grams, and corresponds to the equation,

$$ZnS + CaO + C = Zn + CaS + CO$$

No. 4 contained zinc blende, 97; silica, 120, and coke, 24 grams, and corresponds to the equation,

$$2ZnS + SiO_2 + 4C = 2Zn + SiC + 2CO + CS_2$$

The four charges were placed in separate assay crucibles, loosely covered, and placed in a hot coke fire. Charges 1, 2 and 3 were heated two and three-fourth hours, while charge No. 4 was heated two and one-sixteenth hours. A zinc flame burned from the mouths of crucibles 1, 2 and 3 while they were being heated, but no zinc flame was given off from crucible containing charge No. 4, indicating that no reduction took place in No. 4.

An analysis of charges 1, 2 and 3 after heating showed that about 55 per cent of the zinc had been reduced and volatilized in each case. A practically complete reduction and volatilization of the zinc takes place when either charge 1, 2 or 3 is heated in an enclosed electric furnace, with a current of 50 amps. and 30 volts for 2 hours or less.

Only 5 per cent of the zinc in charge No. 4 was lost during the heating. This loss was probably due to mechanical loss in removing the ignited charge from the crucible after firing.

A charge made up in the same proportions as in No. 4, but containing zinc blende, 194; silica, 260, and coke, 48 grams, was heated in an enclosed electric resistance furnace for 1 hour, with a current of 120 amps. and 50 volts. Only a very small amount of metallic zinc (about 1 gram) was found in the condenser, and an analysis of the powder which collected in the condenser showed that it contained only about 4 per cent more metallic zinc than the charge which was placed in the furnace. The material remaining in the furnace after heating contained 3.98 per cent of metallic zinc.

These data show that zinc sulphide is not reduced to metal when mixed with silica and carbon and heated to a very high temperature. The temperature attained in this experiment was high enough to volatilize most of the charge out of the furnace, yet the zinc ore was not reduced to metal.

The authors conclude that it is a question of only a few years that the electric furnace will be a commercial accomplished fact in the zinc industry. Two lines are promising. First, roasted zinc ores may be smelted in the electric furnace with coke or coal and just enough other material to form with the impurities an easily fusible slag, which may be easily tapped from the furnace. The advantages of the electric process are that it can be made entirely continuous, that the walls of the furnace can be constructed of materials impervious to zinc vapors, and not corrugated by the slag so that the temperature may be raised to a point at which all of the zinc will be expelled from the ore, and the saving of energy due to the application of the heat internally. Ores high in iron and other impurities could be easily smelted, since the walls of an electric furnace can be made of materials which will withstand the corrosive action of the slags.

A second line of possible commercial developments would be in the smelting of zinc sulphide in the electric furnace without the preliminary roasting, by mixing ore, lime and carbon in proportions required for producing metallic zinc, calcium sulphide and carbon monoxide. The fused calcium sulphide could then be tapped from the furnace and the sulphur subsequently recovered. All but traces of zinc can be distilled from such a charge.

The paper was briefly discussed by Prof. C. F. Burgess, who said that the endeavor to make calcium carbide and zinc simultaneously in the electric furnace contradicts the fundamental metallurgical principle that it is impossible to carry out in a single apparatus simultaneously two reactions which require very different conditions for their most efficient operation. Dr. J. W. Richards thought that pyrometric measurements would have given very interesting information, and pointed out that the reactions (*a*) and (*b*) are strongly endothermic reactions. He also presented some notes communicated by Mr. Woolsey McA. Johnson.

Mr. W. McA. Johnson's remarks deal with general considerations of the zinc market and look into possibilities of future improvements in this line. He points out that in the past ten years all metals have shown a wonderful increase in production, and, of course, in consumption in the United States. The figures average a yearly increase of 7 to 10 per cent per year. Of course, in ten years 7 per cent increase compounded will mean a doubled production. This fact is bound up with our great industrial expansion since 1896, and perhaps the figures 7 per cent less certain correction charges for insurance was the normal rate of interest for the capital invested in metallurgical industry. Mr. Johnson points out that since zinc is made in small retorts of a capacity of 50 pounds of ore and a daily production of some 20 pounds of metal, for these reasons zinc was restricted in its normal growth. Whereas the copper, iron or lead furnace could put through an enormous tonnage of ore with no increased labor charge per unit as size increased, the zinc business was held rigid and fast by the smallness of its unit. Mr. Johnson also makes some suggestions as to the limited market for spelter. Spelter has only one indispensable use, namely, brass making, and its great use for galvanizing is restricted by the fact that any increase in the price of spelter increases the price of galvanized sheets to such an extent that construction work will be preferably done with ordinary black sheets.

He also points out that fire-clay, labor and coal have advanced in price immensely the past ten years, and that this, with the lower grade of zinc ores used, increases the cost of producing spelter to an extent not marked in the other metals as lead, iron and copper. Now, there are several possible means for improvement in this line. First, an improvement in the old retort which Mr. Johnson thinks has possibilities not known to those who had not practical experience in the zinc business. He also points out that great progress is being made in the mechanical concentration of low-grade zinc ores, and makes reference to the electromagnetic and electrostatic separators. Attention is also called to possibilities of the pressure blast furnace and also to the old blast furnace used for the production of a high-grade oxide, to be retreated in the old retort. Mr. Johnson dismisses as impractical the leaching with subsequent electrolysis and also the Swinburne-Ashcroft process; in view of the fact that so much has been written and so much claimed about these processes, he thinks that no material evidence of their success is a proof that they are impractical. Reference is also made by Mr. Johnson to the electric furnace with which he, as is quite well known in the business, has made extensive experiments.

The electric furnace, it is pointed out, is especially adapted, as all electrical and metallurgical processes are, for the refining of a crude material previously made. This has been the experience of the electric steel furnace, the electrolytic lead process, the electrolytic nickel process, and the electrolytic copper process. In general, it may be said that electricity is an expensive agent, and should only be used for putting on the finishing touches. Mr. Johnson says in conclusion that while he does not think the treatment of ores in the electric furnace to be impossible, yet he now thinks it is fraught with great metallurgical, practical and commercial difficulties.

Electrometallurgy of Antimony.

A paper on this subject was presented in abstract by Mr. Anson G. Betts. Since antimony ore quite often contains gold, the question of the purification of crude antimony is quite interesting.

Acid ferric chloride solution is said to attack stibnite with ease, producing a solution of ferrous and antimonious chlorides and a residue of sulphur, and from this solution metallic antimony and ferrous chloride should be recovered by electrolysis. Mr. Betts has applied the same idea to the treatment of crude antimony and has found that the electrolytic operation can be quite easily carried out. Carbon anodes and copper or lead cathodes may be used. To avoid the necessity of using a diaphragm for the separation of the anode solution of ferric chloride and the cathode deposit of antimony, the following precautions are taken. The ferric chloride generated at the anode is heavier than the main solution, and continually runs down the anode surface and collects at the bottom of the cell, whence it may be drawn off, while fresh ferrous chloride-antimonious chloride is added at the top.

Mr. Betts operated with a current efficiency of 90 per cent. The electromotive force of the element $Sb\text{-}SbCl_3.FeCl_2\text{-}SbCl_3.FeCl_2\text{-}C$ is about 0.75 volt. The solution should be quite strongly acid to prevent the deposition of antimony oxychloride from the solution as a white precipitate.

Mr. Betts then passed to the discussion of antimony trifluoride which is much superior to antimony trichloride for electrochemical purposes. When a solution of it is electrolyzed with insoluble lead anodes, the main action at the anode is the liberation of oxygen as gas, and the formation of hydrofluoric acid in the solution. When iron is present a good deal of ferric salt is formed, particularly with low anode current densities.

Antimony oxide is obtained in some metallurgical operations, such as the roasting of antimony sulphide, and this may be dissolved in hydrofluoric acid and electrodeposited from the solution with lead cathodes and lead anodes as a beautiful solid deposit, and, if the solution is free from copper and antimony, of high purity.

Copper may be said to be the most troublesome metal in the electrometallurgy of antimony. In the chloride solution it stands very close to antimony in the electromotive force series, but in the fluoride solution it stands below antimony, and may be precipitated from solution by antimony. The explanation of this appears to be found in the fact that copper will exist in the fluoride solution only as a cupric ion, which has a different electromotive force of solution from the cuprous ion of the chloride solution.

Mr. Betts finally made some remarks on the electrolytic refining of antimony. The chloride solution is not supposed to be suitable. When the fluoride solution was first tried, alkaline sulphates and sulphuric acids were added to improve the conductivity. There were, however, troubles, and these Mr. Betts has traced to the presence of the sulphion.

With the omission of sulphion there is no difficulty at all. The anodes as readily dissolve as copper or lead anodes and the cathode deposit of antimony leaves nothing to be desired. No analyses have as yet been made of the antimony, but there is no reason to think that it is not very pure. These deposits do not tarnish at all, even in a laboratory full of fumes, when other metals tarnish badly, so that an electrolytic coating of antimony should be very useful as a protection against corrosion, especially on objects which are not bent, as the antimony coating is very brittle.

Pyrometer.

Mr. F. F. Schuetz then briefly described and demonstrated a new Bristol thermoelectric pyrometer which has certain distinct practical advantages. The thermoelectric couple is made separately from the leads to the instrument (which is a Weston instrument), and is connected with the leads by means of a flexible joint. If the couple should be hurt, it is easy to replace it, without replacing the leads themselves. It is possible to place quite a number of thermo-couples at different points of the furnace, and measure the temperature at these different points with one single instrument. We hope to describe the instrument at greater detail in a future issue.

Excursions to Plants of New Jersey Zinc Co. and Bethlehem Steel Co.

At 12.30 the visiting members and friends were entertained at luncheon by the Trustees of Lehigh University in the Gymnasium. Afterwards a group photograph was taken in front of the university chapel.

At 2 P. M. a start was made for the zinc works of the New Jersey Zinc Co. of Pennsylvania. Here the party were met by the genial manager of the works, Major de Saulles, and inspected the plant. The zinc ore, obtained mostly at Franklin, N. J., is there magnetically concentrated, and comes to the works as magnetic heads, rich in iron and manganese, and the willemite tailings, almost free from impurities. The former are treated in long runs of Wetherill "blowing hearths," in which, on a bed of anthracite, the zinc is volatilized, and rising from the hearth is burned by air to zinc oxide. The latter is drawn off by powerful fans and forced into the long bag filters, which are 30 inches in diameter by 40 feet long, and of which several hundred are used. The product is white zinc oxide paint material. The residue from these hearths is reduced in a small blast furnace to spiegeleisen, carrying 15 to 20 per cent of manganese. The visitors were fortunate enough to see the operations of tapping both slag and metal.

The other part of the plant was then visited, where willemite ore is reduced in retorts to metallic zinc. The operation of making a retort in a hydraulic press was watched with interest, and the large gas-fired Belgian retort furnaces with long runs of retorts were inspected with great attention, the small scale of the units used and the large amount of labor required being objects of wonderment to those seeing them for the first time.

It really does seem as if modern large-scale methods are constitutionally inapplicable to the present metallurgy of zinc.

The party then passed into the adjoining plant of the Bethlehem Steel Works, where between 7000 and 8000 men toil night and day, and iron and steel are transformed from dull red ore to brightly polished shafts and guns. The eighteen large open-hearth furnaces, capable of producing 1000 tons of steel a day, the powerful steam hammers forging massive bars, the still more powerful hydraulic presses squeezing 2 feet of red-hot iron like cheese, the 8000-ton hydraulic press, under which the fluid steel was placed under compression to set solid, the immense steel foundry, where patterns as large as the side of a house were being moulded into refractory sand to make 50 and even 80-ton castings, all impressed and almost overpowered the visitors by their titantic strength and massive proportions.

On the next building were seen an overwhelming display of guns in all stages of manufacture, shafts, cranks, machinery castings, 1800 x 400 feet of space, filled as closely as possible with the finest of modern machinery turning out the finest of modern steel work. A glance at the iron-casting shop and a visit to the mechanical and chemical laboratories found the available time exhausted, and most of the party also ready to admit that the excessive heat and consequent bodily fatigue rendered them incapable of further sightseeing.

Assistant Manager Acker, Superintendents Rawle and Wright and Messrs. Heilig, A. D. Meixell, L. N. Meixell, Brush, Wright, Hartz and Kautz were the all-efficient guides on this most enjoyed expedition.

Banquet.

On the evening of Tuesday a subscription banquet was held in the Eagle Hotel. It was very greatly enjoyed on account of its familiar and informal nature. Dr. J. W. Richards proved to be an excellent toastmaster. In his opening remarks he said that, as its founders predicted, the American Electrochemical Society had not weakened any single one of the older electrical and chemical societies, but had on the contrary done excellent work by bringing them together; the society has been successful in getting as members advanced men from all the branches which it represents.

Dr. Wilder D. Bancroft made a very happy speech, full of humorous and pertinent epigrams. He mentioned the more important resolutions which had been adopted the day before at the directors' meeting, and which are mentioned above in the first part of this report. He extended a very hearty invitation to the society to hold its next meeting at Ithaca, and promised that although they could not show the members "the inside of a big zinc plant or steel plant nor the outside of an electrochemical plant," there were some interesting industrial developments in Ithaca, and then there is, of course, Cornell University. Prof. W. S. Franklin told some good jokes about the last meeting in Boston and about bygone days he spent in Berlin.

Prof. A. G. Rau blew the horn (or rather the trombone) of Bethlehem, and spoke in a most interesting way of its history, of the culture of music and of the general uplifting of the community by the Moravians. Mr. Acker, of the Bethlehem Steel Co., gave a sketch of the wonderful development of these world-renowned works, which now employ 7000 to 8000 men, and expect to employ in few years 10,000 to 15,000. Mr. H. B. Coho, in behalf of the strong New York delegation, made a felicitous, humorous speech, and celebrated Bethlehem as an economical city, referring to the 1-cent toll on the bridge to the university in South Bethlehem. Mr. C. F. Carrier, Jr., spoke of his years of study in Germany, and discussed the difference in the way Americans and foreigners look upon scientific subjects. Mr. A. von Isakovics, as secretary of the New York section, was pleased to see New York so well represented.

After the banquet there were songs in the parlor of the Eagle Hotel, with Dr. G. Drobegg at the piano. This was followed by a meeting of the "Free Ions" at the Brighton.

WEDNESDAY MEETING.

Specific Resistance of Electrolytes.

The first paper presented related to a standard method of determining the specific resistance of electrolytes, the author being R. Threlfall, F. R. S. He uses essentially the potentiometer method and connects the potentiometer with the electrolytic resistance to be determined by means of single reversible electrodes, such as that of Ostwald. The author claims for his method a high degree of accuracy.

The essential part of the apparatus consists of a uniform glass tube, which contains the electrolyte under test, into which are fitted an each end two glass T-pieces. The vertical branches of the Ts give access to platinized electrodes, which are connected to a storage battery in series with a high resistance. The horizontal branches of the Ts are used to fix the position of the testing electrodes of glass tube drawn down to long, fine points. These testing electrodes are connected in the usual way through two beakers with the Ostwald standard electrodes. The tube containing the electrolyte is immersed in a large bath containing heavy mineral oil and provided with a heating coil running the whole length, and with a shaft with screw paddles also running the whole length of the trough.

It is stated to be an essential part of the method, both that the main current is reversed after a group of observations and that several sets of comparisons are made alternately with the current, first in one direction and then in the other. The effect of taking an arithmetical mean of the results is to eliminate differences of potential difference in the single electrodes and intermediate contacts.

The paper was discussed by Prof. Burgess, who described a somewhat similar method used in his laboratory at the University of Wisconsin, also using Ostwald normal electrodes. Mr. Hering spoke of some possible sources of error in Threlfall's method, and recommended the use of gold electrodes, which he has found to be non-polarizable. Mr. Easterbrooks said that as high a degree of accuracy as is obtainable with Threlfall's method, is not necessary in the routine work of a metal refinery where quick volumetric methods are used for determining the composition of the electrolyte. An apparatus similar to that of Burgess' has its advantages in that it is simple in construction, and a curve can be plotted in less than half an hour.

Electrochemistry at St. Louis Exposition.

A paper on this subject, by Prof. C. F. Burgess, was read by title. It comprises a combination of the notes made by the group jury for electrochemistry in connection with its study of the electrochemical and electrometallurgical exhibits at the exposition.

Reversible and Irreversible Polarization.

A second paper by Prof. W. S. Franklin and L. A. Freudenberger was presented by Prof. Franklin. The first paper by the same authors on the same subject was abstracted on page 171 of our present volume. The fundamental idea of the authors is to consider the e. m. f. of an electrolytic cell as the sum of three factors:

$$E = Ri + f(i) + e,$$

where E is the total e. m. f., Ri is the e. m. f. consumed by the ohmic resistance, $f(i)$ the irreversible polarization, which is a function of the current, and e the reversible polarization, which is not a function of the current.

The authors formerly tried to measure the total e. m. f. across the cell at the instant of starting the current, so that the reversible polarization e would be zero; hence, knowing the value of Ri it would be possible to find the value of the irreversible polarization $f(i)$.

In order to find the original value of E at the instant of starting the current, the curve of growth of total voltage with the time was determined, and the intention was to exterpolate to zero time. But the curves given in the present paper show a sudden rise of voltage immeditely after the closing of the circuit, which makes it impossible to extend the curves to zero time with accuracy.

Another method was then tried by Messrs. Blume and Fleming, by which the reversible polarization e was to be determined with considerable accuracy, thus enabling the values of the irreversible polarization $f(i)$ to be inferred from the total e. m. f.

A certain value of current was started through the electrolytic cell and allowed to flow for t seconds, when the voltage between the cell terminals was measured. From the voltages so determined the calculated value of Ri is subtracted, and the result is plotted as ordinate of curves marked A in the paper. The abscissæ are values of t. The electrolyte was then vigorously stirred, the same value of current again started through the cell and allowed to flow for the same length of time, when the circuit was suddenly broken and the residual voltage between the cell terminals immediately measured. This residual voltage is assumed to be the value of the reversible polarization e at the instant t, and this residual voltage is plotted as an ordinate of curves marked B in the same diagram. The elapsed time between the breaking of the circuit and the measuring of the residual voltage was about 0.01 second.

The best that can be done to find the values of the irreversible polarization from these curves is to take the mean difference of the ordinates of the A and B curves.

The A and B curves were determined for up-flowing current as well as for down-flowing current. Horizontal parallel electrodes were used.

The paper was discussed at some length by Messrs. Burgess, Hering, Bancroft and Betts. Prof. Burgess suggested to use alternating current and to investigate the distortion of the wave form. He also doubted whether the transfer resistance between the electrode and electrolyte had been taken into account by the authors. Mr. Hering doubted whether the subject could be treated by means of such a simple formula as is the foundation of Prof. Franklin's method. The latter replied at some length.

Ammeters for Electrolytic Work.

A paper by Mr. Lawrence Addicks, of the De Lamar Copper Refinery, was read, in the absence of the author, by Mr. Easterbrooks. In view of the cost of power for a large proportion of the total cost in many electrolytic operations it is important to have the switchboard instruments correct to 99 per cent. Especially with the ammeters, certain precautions must be taken.

When several thousand amperes are to be measured, care should be taken to place both shunt and instrument in suitable positions when designing the switchboard. In the first place the shunt should be obtained from the maker with short bars inserted in the slots usually provided in the shunt terminals, these bars in turn to be bolted to the bus-bar carrying the current to be measured. In this way the shunt is calibrated with the same distribution of current through the various leaves as will be the case in after use.

Unequal heating of the two shunt terminals will introduce a constant error from the thermoelectric junctions formed where the alloy leaves are soldered onto the copper blocks. This may easily amount to 1 per cent of the full scale reading, may be either positive or negative, and will show as a zero error on shutting down the circuit, which will gradually disappear as the shunt cools off. Sometimes compensating devices are applied to avoid thermoelectric errors, but if the shunt is so placed in the bus-bar that the facilities for conducting away heat are approximately equal on both sides, there will be no appreciable error, and such devices should be unnecessary. The alloy leaves of a shunt would be red-hot at full load were it not for the heat dissipating qualities of the large copper terminals. There should be practically equal radiating surfaces of bus-bar for 3 or 4 feet each side of the shunt. If placed close to a switch on one side, there is sure to be a thermoelectric error in the shunt, as high capacity switches frequently run hot. The best plan is not to attempt to place the shunt back of the switchboard at all.

The temperature at which a shunt runs will repend upon how heavily it is loaded and the opportunity afforded to dissipate the heat generated. The temperature indicated by a thermometer and well placed upon one of the terminal blocks should not be allowed to exceed 200° F., owing to the danger of starting the solder and consequent failure.

The power wasted by a 5000-amp. shunt at full load is about 300 watts. It is perfectly practicable to build a shunt for 25,000 amps.

The author then passed over to a discussion of the instrument itself.

One of the most important sources of error is the magnetic effect of stray field in the immediate vicinity of a bar carrying several thousand amperes. Instruments should never be placed within 2 feet of such bars. The iron is not only likely to be faulty as a filter for lines of force of such density, but consequent poles are formed in the case itself. The author has found instruments placed in the vicinity of a stray field of such strength that he could hang his bunch of keys from the case.

The resistance of the leads is generally some 5 per cent of that of the instrument, and the screw connections must be kept clean. If it is found necessary to lengthen the leads, care must be taken that the resistance is kept constant by a proportionate increase in size of wire used.

The leads should be twisted and kept from swinging loosely in the presence of stray field.

When several high-capacity ammeters are in use, it is advisable to have them interchangeable.

Incandescent Lamps

A paper on the thermodynamics of the electric incandescent lamp was presented by Dr. E. F. Roeber, who also exhibited in operation the latest three types of incandescent lamps: the osmium lamp of Auer von Welsbach, the tantalum lamp of the Siemens & Halske Co. and the new graphitized filament lamp of the General Electric Co., invented in its research laboratory under the direction of Dr. Whitney.

The first part of the paper was a summary of the laws of radiation of a black body, as applied to electric incandescent lamps. A black body is one which is impartial in absorbing and emitting waves of all different wave lengths; it absorbs all, and therefore it emits all.

The author first connected the electrical energy supplied to the lamp with the total energy of radiation given out by the lamp according to the Stefan-Boltzmann law. The total radiation increases with the fourth power of the temperature. With increasing temperature the wave length, which has the maximum of energy, is shifted toward shorter wave lengths, *i. e.*, toward the visible spectrum, according to Wien's displacement law, which states that the product of absolute temperature and wave length of maximum energy is constant. The distribution of the energy within the total spectrum is given by laws of Wien and Planck. All these laws are strictly correct for the black body. They are the foundation of optical pyrometry, which is now assuming such importance in metallurgy. The author called attention to the excellent treatise on optical pyrometry by Waidner and Burgess in No. 2 of the Bulletin of the Bureau of Standards.

A review was then given of the researches tending to determine the mechanical equivalent of light, and it was explained that the physical and the physiological aspects of the question must be clearly distinguished. The author then dis-

cussed the possibilities of improving the efficiency of incandescent lamps. This is possible by increasing the temperature of the incandescent filament, which has been indeed the fundamental idea on which the osmium lamp and tantalum lamp were developed. However, in this direction it is practically impossible to get the maximum of the energy emitted by the filament within the visible spectrum. A second possibility is to get away from the black body and to use a filament with selective radiation. The departure of a filament from black-body radiation depends essentially on the substance used; it also depends, however, on the polished condition of the surface, since the more porous the surface of a filament, the more will it behave like a black body.

The necessity of using high temperatures and of employing pure substances (since the addition of any impurity lowers the melting point) indicates the intimate relation between the invention of new incandescent lamps with electrochemical research. The author showed the rôle which electrochemical methods have played in the invention of the three lamps which were exhibited. Concerning the tantalum lamp, see our March issue, page 118; concerning the graphitized filament, our July issue, page 252. In the preparation of the osmium filament, first threads are made consisting of porous rough osmium with an organic binding material; they are dried and heated in the absence of air to carburize the binding material. The carbon is then removed by heating the thread by the electric current in an atmosphere containing much steam and larger or smaller quantities of reducing gases. The carbon is removed by the same reaction by which water-gas is made.

The paper was discussed by Messrs. Bancroft, Hering, Franklin, Richards, Brown and Thatcher. The discussion dealt mainly with problems of optical pyrometry and with the question whether the black deposit on an incandescent lamp is due to actual volatilization of carbon. Prof. Franklin pointed out that for realizing selective radiation, gases appear to be most promising at present.

RADIOACTIVITY.

Two papers on this subject were presented by Prof. HERMAN SCHLUNDT and Prof. RICHARD B. MOORE. In the absence of the authors they were read in abstract by Prof. W. D. Bancroft.

The first paper discussed the chemical separation of the excited activity of thorium. The experimental results obtained by the authors show that a separation of the products constituting the excited activity of thorium can be readily made by chemical methods.

After removing the matter deposited on a negatively charged wire exposed for a long period to thorium emanation with acids, ThB may be obtained practically free from ThA with a precipitate of ferric hydroxide by means of pyridine or fumaric acid. The other component, ThA, remains in solution, and upon evaporation it remains as a residue. Ammonia does not make a separation.

By precipitating barium sulphate (or lead sulphate) in a solution of ThA and ThB, ThA is found in the precipitate. The residue obtained by evaporating the filtrate decays in activity very rapidly, falling to half value in about 56 minutes—the characteristic rate of decay of ThB. The precipitation of silver chloride in an acid solution of ThA and ThB removes very little of either of the components from the solution.

No differences were observed in conducting the separations immediately or after a lapse of time.

The residue from the solution of ThA and ThB obtained by boiling the foils in hydrochloric acid is probably more readily volatilized than the deposit itself or the residue from the nitric acid solution.

A partial separation of the two components of the excited activity may be made by direct treatment of the deposit with an alcohol-water solution of fumaric acid.

The results of the experiments are readily explained by the theory of Rutherford as recently altered by him and Miss Slater. The results of the present authors clearly show that the first stage of the matter constituting the excited activity of thorium is an inactive product, ThA, with the slow rate of change, and that this produces the radio-active product ThB, which changes comparatively rapidly into the final product ThC.

The results harmonize with the conclusion of Rutherford and Soddy, that in the separation of ThX from ordinary thorium compounds, both ThA and ThB are precipitated with the thorium, and the result of the authors, that in the fumaric acid and pyridine separation of ThX the component ThB of the excited activity is simply present in the thorium precipitate.

The second paper gave the results of tests of about twenty samples of mineral waters of Missouri for their radioactive properties. They are mostly mineral well waters, but some deep-well waters, used as water supplies, are also included. The results tabulated by the authors show that marked variations exist in the activity of these cold waters. As a rule, the activity of deep-well waters falls below that possessed by the spring waters.

IODOFORM FROM ACETONE.

A paper by Dr. G. A. ROUSH, on the electrolytic preparation of iodoform from acetone, was then presented. Abbot was the first to get a current efficiency of 60 per cent of iodoform from acetone by electrolysis in an alkaline solution, using a current density of 1.35 amps. per square decimeter and a temperature of 75° C. The catholyte was a 10 per cent solution of sodium carbonate. The anolyte contained 6 grams of sodium carbonate, 10 grams of potassium iodide in 100 cc. water; 5.5 cc. acetone were added at the rate of 0.5 cc. every 10 minutes during the electrolysis.

In 1903 Teeple worked out conditions by which he obtained a current efficiency calculated to be 94.5 per cent. He used no diaphragm, a low anode density and high cathode density, kept the solution cooled, well stirred and slightly acid in reaction. Since the reaction continually sets free alkali he neutralized it by adding gradually iodine during the electrolysis in just sufficient quantity to keep the solution slightly colored. Since this iodine, when added to the solution, forms iodoform, the method is really a combination of a chemical with an electrochemical process, although Teeple calculated his yield as a purely electrolytic yield.

The present author points out that the electrolysis of potassium iodide and acetone without a diaphragm gives two molecules of alkali for each molecule of iodoform produced. On the other hand, electrolysis with a diaphragm yields four molecules of acid for each molecule of iodoform produced. He, therefore, combines both reactions as follows:

The electrolyzing vessel was a crystallizing dish of 350 to 400 cc. capacity. The anode was a platinum crucible, presenting about 15 to 20 square centimeters of electrode surface, fixed on a shaft and rotated at a moderate speed. The rotating anode was used because it was the most efficient means of keeping the solution well stirred. Two cathodes were used. One was a platinum wire about 15 cm. long, 10 cm. of which were immersed in the electrolyte. The other cathode was of copper gauze of about 100 square centimeters surface and was placed in a porous cup. These are designated as the "regular" and "auxiliary" cathodes, respectively. Each cathode was connected to a separate resistance, so that the current could be regulated in one, independent of the other.

In this way the current entering the solution at the anode is divided into two parts, the first passing from the anode to the regular cathode, the second from the anode to the auxiliary cathode in the porous cup. Theoretically, if the current in the auxiliary cathode is one-half the current in the regular cathode, the solution will be kept neutral. In practice, however, the solution is to be kept slightly acid, and the process does not give absolutely theoretical yields; hence the current in the auxiliary cathode is about two-thirds that in the regular cathode, varying with the conditions.

The conditions which, according to the experiments of the author, give at the same time the highest current efficiency and the highest acetone yield, are as follows: Electrolyte, 20 grams KI; 300 cc. water; 1.5 cc. acetone; current, regular cathode, 1.5 amp.; auxiliary cathode, 1.0 amp.; temperature, 15 to 18° C.

Prof. W. D. Bancroft, in discussing this paper briefly, pointed out how much valuable work has been done in connection with this and kindred subjects in recent years—and all this work has been done in this country.

Resistivity of Iron and Steel at High Temperatures.

A note by Mr. Gustave Gin on the electric resistivity of iron and steel at high temperatures, was presented, in the absence of the author, by Prof. J. W. Richards. The author describes the arrangement of his tests and gives the result of the first measurements which he has made with cast iron containing 93.032 Fe, 2.752 Mn, 3.337 C, 0.783 Si, 0.061 P, 0.035 S. The resistivity of this iron was found to be 0.00016 microhm-centimeters for temperatures between 1.280° C. and 1.340° C.

Prof Richards welcomed this paper as one furnishing empirical data of value for metallurgical calculations. He hoped that a great many similar papers would follow.

A vote of thanks, moved by Prof. C. F. Burgess, and seconded by Mr. Carl Hering, and extending the thanks of the society to all those who had made this meeting so successful, especially to the local committee, to the authorities of Lehigh University and to the officers of the different plants visited, was carried enthusiastically.

Before the meeting adjourned, the Society was honored by the presence of Mr. John Fritz, the famous and venerable steel metallurgist, who came to greet the members of the Society.

The excursion to Mauch Chunk for the afternoon had to be given up on account of the threatening weather. Those who remained for the afternoon in Bethlehem attended the impressive opening services in the University Chapel of Lehigh University. Others paid a visit to the plant of the Dexter Portland Cement Company, of Nazareth, Pa. The company met the guests with a special train and conveyed them to the works, some little distance from Nazareth. Dr. R. K. Meade, the chemist of the company, took charge of the guests and showed them around the plant. They started in at the quarry from which the raw material is taken, and followed the same through the plant, first through the grinding department and then the kiln, and finally the final grinding and packing rooms. In all it was a most pleasurable visit, many of the members seeing the manufacture of cement for the first time.

In the following we give an alphabetical list of all gentlemen who registered at the meeting:

C. E. Acker, G. P. Adamson, W. D. Bancroft, F. M. Becket, A. G. Betts, G. Boericke, C. S. Bradley, Wm. Hand Browne, Jr., C. F. Burgess, C. F. Carrier, H. B. Coho, F. Conlin, C. A. Doremus, G. Drobegg, F. D. Easterbrooks, William Esty, Ernest Fahrig, W. S. Franklin, L. A. Freudenberger, W. C. Geer, J. H. Granbery, E. I. Harrington, E. Hart, W. Homer Hendricks, Carl Hering, H. C. Huettig, W. S. Landis, A. B. Larchar, H. T. Matthew, B. MacNutt, John Meyer, J. Y. McConnell, H. Phillip, A. G. Rau, J. W. Richards, E. F. Roeber, C. J. Russell, T. Rynard, S. S. Sadtler, J. W. Schade, F. F. Schuetz, William Smith, C. C. Speiden, M. Toch, F. J. Tone, R. von Foregger, A. von Isakovics, Leonard Waldo, E. H. Whitlock, W. E. Winship.

Lehigh University.—The twenty-sixth celebration of Founder's Day will take place on Oct. 12. The Founder's Day address will be delivered by the Hon. Hampton L. Carson, Attorney-General of Pennsylvania. In connection with these exercises will occur the inauguration of Mr. Henry Sturgis Drinker as president of the University. The installation address will be delivered by Mr. Robert H. Sayre, president of the Board of Trustees, while Mr. Frank P. Howe, Lehigh '78, will speak for the alumni. These exercises will be followed by the turning of the sod for Drown Hall.

Action of Acids on Iron and the Use of the Acid Pickle.

By Charles F. Burgess.

(*Concluded from page* 335.)

Hydrochloric and Sulphuric Acids.

Hydrochloric and sulphuric acids are the most important materials used in pickling, the latter being far in the lead so far as the total quantity consumed is concerned. The pickler has his choice limited, practically, to these two acids, though he has a wide range of densities and purities to select from. The determination of what is the best composition for solution is influenced by a number of factors, including the relative costs of the acids, the nature of the iron or steel to be treated, the quantity and thickness of the scale, the purpose for which the cleaning is to be done, the cost of labor, the size of plant and the utilization or disposal of waste.

So far as cost is concerned, sulphuric acid is ordinarily considerably cheaper than hydrochloric. The former is obtainable at a density which closely approaches 100 per cent acid, while the hydrochloric acid solution contains about 40 per cent of dry HCl gas. On the basis of pure acid content, 1 pound of pure sulphuric acid has the capacity of dissolving .57 of a pound of iron, while a pound of pure hydrochloric acid will dissolve .77 of a pound. One pound of commercial hydrochloric acid has the dissolving power, as compared with sulphuric acid, of about 10 to 19. There are certain localities where muriatic acid can be produced as a by-product and supplied at a much lower price than that asked for sulphuric acid, but where transportation charges must be reckoned upon as a factor, the price of hydrochloric acid increases much more rapidly than does that of sulphuric acid, since it must be transported in glass-containing vessels, while the other may be shipped in large iron tank cars.

The determination of the strength of acid solutions to be employed is a most important factor, since upon it depends the rapidity with which the work may be done, and, therefore, the size of the plant which becomes necessary. It is generally assumed that the rapidity with which a solution will act will be somewhere nearly proportional to the percentage of acid in aqueous solution. That this rule can be applied only with reservations, at least so far as sulphuric acid is concerned, is shown by some important data which R. Kneitsch has given in a paper on "Sulphuric Acid and Its Manufacture" in Vol. X. of *The Mineral Industry*. He studied the action of various strengths of acids upon wrought iron and cast iron, and gives data and curves showing in what manner the rate of corrosion varies with the density. The curve showing the rate of corrosion of sulphuric acid in progressively increasing strengths is not a simple one, possessing a number of maxima and minima.

Some interesting comments are made by the same author upon the action of the acids upon cast iron. He states that while cast iron vessels are well suited to using for watery sulphuric acid, they cannot be used with fuming acids, for though cast iron is attacked but little, what is worse, it explodes. This remarkable property is based upon the fact that the fuming acid, diffusing in the pores of the cast iron is reduced to sulphur dioxide and hydrogen sulphide, sometimes even generating carbon dioxide from the carbon of the iron. All of these are gases, the critical temperatures of which are low, and which, as a result, cause high tensions within the iron.

A curve which would show the action of various strengths of hydrochloric acid would not be so complicated as the one given for sulphuric acid. This is probably due to the fact that the strongest liquid hydrochloric acid that is available contains only 40 per cent of HCl, while sulphuric acid is readily obtainable up to 100 per cent strength, and is even then capable of dissolving a considerable amount of additional SO_3. At no

point in the concentration of HCl does iron become passive, and it is for this reason that iron vessels cannot be used for its storage and transportation as is done with sulphuric acid.

Practice shows that hydrochloric acid can be used in a higher degree of dilution than can sulphuric acid, and this constitutes a marked advantage in its favor. The action of a less than 10 per cent solution of sulphuric acid becomes so slow as to be prohibitive in most cases, and the pickle, therefore, becomes "spent" while there is yet a considerable percentage of free acid in the solution. Consequently, the available part of the acid is that which lies above the percentage at which the action on the iron becomes so slow as to prohibit its use. The amount of free acid which goes to waste in the spent pickling liquor constitutes, on this account, a large item in the total consumption of acid. Such waste may be decreased somewhat by heating the solution. With hydrochloric acid, on the other hand, a more dilute solution retains its activity, and consequently the acid may be used to a higher degree of efficiency.

It is a noticeable fact that most of the authorities, while stating what strength their pickling solutions should have, neglect to give the degree to which it may be exhausted. This is a most important factor in calculating for acid consumption, and it is a point upon which additional information is very desirable. While investigations have been made to determine the rate at which freshly prepared acid solutions will dissolve iron, the writer has been unable to find any data showing the influence which dissolved iron salts in a solution may have in affecting this rate. As pointed out heretofore, it is a well-known fact that the presence of metallic salts in an acid solution will have a marked effect on the activity of the solution, but an investigation of the effect of the dissolved iron salts is a subject worthy of further effort.

To increase the percentage consumption of the acid, the freshly prepared solution should be as concentrated as is possible and compatible with vigorous and effective corrosion, for in this manner the percentage of acid which is lost in the waste liquor bears its smallest ratio to the total amount of acid employed. A limitation, however, is placed upon the density available by the solubility of the iron salts which are formed, since, if this reaches the saturation point, the action of the acid is greatly diminished or ceases, this being due to the formation of insoluble iron salts on the surface of the metal. The chlorides of iron being much more soluble than the sulphates, the hydrochloric acid solution may have a higher concentration.

The use of temperatures considerably above ordinary room temperatures, which is recommended by many picklers, is due to the well-known fact that the activity of an acid is increased at higher temperatures, and also because the products of corrosion have their solubility increased in a like degree. Heating, then, enables the acid to be used more efficiently and effects a saving in the size of the plant necessary, but it is not always employed, on account of the complications arising in the construction of the plant by the introduction of heating coils or the changes in construction necessary to make the containing vessels withstand the action of the acid. The best way to effect such a heating is to inject steam directly into the solution, but this is not always permissible on account of the diluting effect of the condensed steam.

The purity of the acid used is a matter to which, of late, picklers have given more attention than formerly, as it is now recognized that this detail plays a most important part in the economy of the process. For a long time it has been known that the acids obtained from some manufacturers are more satisfactory than those made by others, though the reason for this difference in quality has not always been understood by the users. The impurity which seems to affect in the greatest degree the usefulness of sulphuric acid is arsenic, and frequently picklers now specify that the acid they purchase shall be free from this impurity. Such acid, however, usually commands a higher price, which in certain cases is quite justifiable. As previously pointed out, the effect of arsenic in an acid solution is to decrease the rate at which it will attack iron, and since upon the attack on the iron depends the removal of the mill scale the presence of arsenic greatly interferes with such removal. But while arsenic is decidedly disadvantageous in such connection, it may play a useful part under other conditions which will be dwelt with later. Arsenic is an impurity which is found to greater or less degree in acids made from pyrites, and is not usually present in that made from burning sulphur. This accounts for the preference which is commonly given to brimstone acid.

In addition to decreasing the activity of the acid, the arsenic is by some supposed to be responsible for the black stains which remain on the iron after the scale has been removed. Just why the presence of arsenic interferes with the action of the acid, or just what is the nature of the black deposit which it forms, are matters that do not seem to be well understood, and which are, consequently, fruitful subjects for further investigation. If it could be shown that the addition of arsenic prevents the corrosion of the iron, while at the same time it does not diminish the dissolution of the oxide, we would have a possible method pointed out for obtaining a pickling solution closely approaching the ideal. There seems to be, however, no available data showing the relative influence of arsenic on the solubility of iron and its oxides. As to the black stains for which it is supposed to be responsible, it is probable that remedies could be discovered as soon as their nature and causes are better understood. Some investigations which are now under way in the writer's own laboratory indicate that certain substances other than arsenic may be productive of all the advantages exercised by arsenic with entire freedom from its disadvantages.

Most of the other impurities commonly found in acids do not play such important parts. The presence of copper, silver and platinum, it is well known, increase the rate of attack on iron, but this increase does not seem to be advantageous in pickling, since it increases the rate of corrosion on the iron which has been cleaned of scale, while it does not increase the rate at which such scale is removed. Iron will readily dissolve in a copper chloride solution, but without any appreciable removal of scale, since there is no liberation of hydrogen and the mechanical action of hydrogen in forcing the scale away from the iron is an essential in the pickling process.

The process for pickling iron and steel presents, as has been indicated, various problems of both interest and importance, the solution of which will contribute to the improvement of methods now in vogue. One of the most important ways in which present methods could be changed for the better would be in a reduction of acid consumption. An ideal pickle would be one in which all of the acid is utilized by being consumed in the dissolution of rust and scale without dissolving any of the iron. This seems to be impossible of attainment, since we know of no solvent for iron oxide which is not a better solvent for the iron itself. But laying aside this factor, material improvement in the manner of operation now followed could be effected by more attention being paid to the choice of a suitable density of solution and to its heating. One of the ways in which acid is needlessly wasted is in allowing the portions of undissolved scale which become detached to fall to the bottom of the tank and remain there, the slow action of the acid continuing to dissolve the material and the acid thereby being wasted. Cowper-Cowles has devised an ingenious arrangement for diminishing this loss by providing a magnetic scale collector which removes the black magnetic iron oxide from time to time as it settles to the bottom of the tank (Electrochemical Industry, March, 1903, p. 263).

The reduction of labor is another important desideratum, since the frequent handling of the material, both in the cleaning operation and in its subsequent brushing and drying, involves a large item of expense. Automatic machinery is being introduced for this purpose to some extent, but under present

conditions of operation it does not seem possible to greatly decrease the amount of labor required. The greatest trouble appears to lie in connection with the washing of the iron after pickling, the neutralization of the remaining traces of the acid and the scouring necessary to remove the adhering particles of insoluble material.

Although little attention has been given here to the operations following the actual pickling process, they must be carefully studied. It is known that with a given grade of iron one acid will leave a cleaner surface than another acid, and the reason back of this demands a study of the action of acids upon the various constituents of iron and steel. Even after the removal of the oxide from the surface a coating of more or less adherent particles will be found, which have a black, brown or grayish appearance, varying with the character of the metal. This deposit is commonly supposed to be due to the carbon which was originally contained in the iron.

Within recent years some important work has been done along the line of investigating the action of various acids upon the innumerable constituents of iron and steel. While the result of this research has been to throw additional light upon the physical and chemical composition of iron, it also furnishes information of use to the pickler in studying the various problems which present themselves. An excellent summary of this work is given by Jüptner in "Siderology: The Constitution of Iron Alloys and Slag."

The technical varieties of iron contain a number of other elements, the chief ones being carbon, silicon, sulphur, phosphorus and manganese. These substances may be either physically or chemically combined with iron, and among the properties which they influence may be included that of corrodibility by acids. Carbon exists in various forms, including graphite, graphitic tempering carbon, hardening carbon and carbide carbon of various kinds. Since graphite is unattacked even by certain boiling concentrated acid, this material, when present in iron, is left as a black deposit upon corrosion by such acids. Graphitic tempering carbon behaves as does graphite in the presence of acids. Carbide carbon in which the carbon is in chemical union with the iron, and which exists in all kinds of commercial iron, when heated with strong acids disengages the carbon as a hydrocarbon. If a specimen of iron containing it is dissolved in very dilute hydrochloric or sulphuric acid at ordinary temperatures, with exclusion of air, the carbide is left behind in a brown or gray mass, which, according to Müller (*Stahl und Eisen*, 1888, p. 292), consists of granules of silvery luster, igniting spontaneously at a relatively low temperature on drying. On dissolving the sample of iron in cold dilute nitric acid of 1.2 s. g., a flocculent brown residue forms. Hardening carbon on dissolving in dilute hydrochloric or sulphuric acid gives off a strong-smelling hydrocarbon gas, and in cold nitric acid leaves a deep black residue.

The amount of residue which is left on dissolving by acids decreases with the concentration of the acid used. Nitric acid leaves more residue than do the other acids, as there is no liberation of hydrogen with which the combined carbon can unite to form hydrocarbon gas. Acids of different strengths leave cast iron with various appearances, since each form of carbon requires a special strength of acid to liberate it from its associated element.

From observations such as these we may draw explanation for many peculiarities noted in the operation of pickling processes. It can be seen why a piece of iron before and after being hardened is affected differently by the acid, why one acid will leave the iron perfectly clean, while another will leave it covered with a black, powdery deposit, and why strength of solution and temperature play such important parts. We may also draw from these observations additional argument for the use of hydrochloric rather than sulphuric acid, since it is seen that the former acid is the better solvent for the combined carbon.

If we may judge from the patent literature and from various articles in the technical press, various attempts have been made to employ the electric current as an aid in pickling. By using the article from which the scale is to be removed as the anode in a solution of sodium chloride, sodium sulphate or other suitable electrolyte, the iron may be corroded, but the fatal defect in this process is that the scale is not thereby loosened, since there is no liberation of hydrogen and consequently no tendency towards lifting off the scale. If the current is made to take a reverse direction and hydrogen is liberated upon the iron, serving as a cathode, the object sought is not attained, since the hydrogen is liberated, to a large extent, on the outside of the scale, which is a good conducting medium. The current is thus used to little advantage. The action of the ordinary pickling solutions may be facilitated by the action of the electric current, but the expense of the electrical energy and the difficulty of connecting the material to be treated as an electrode are such as to make the use of the current impracticable.

When a pickle has been used long enough to become spent, or exhausted, the question arises as to what shall be done with it. If it is to be simply thrown away, the locality determines whether the free acid be neutralized or not. Neutralization can be most cheaply effected by lime, which gives an insoluble precipitate with the sulphate solution and a soluble salt with the chloride. The spent solution contains, however, materials of value, and much attention has been given to methods of utilizing them. With sulphate solutions, the free acid may be neutralized by scrap iron and the resultant solution evaporated down until the ferrous sulphate crystallizes. This method furnishes most of the ferrous sulphate now upon the market. The supply of this material, however, exceeds the demand, so that the revenue derived from its sale does not pay for the acid consumed, it becoming frequently a doubtful matter as to whether the additional cost of plant and labor is warranted by the results obtained. Only the larger plants find the method profitable.

Many plans have been proposed for making a profit from this waste material, but the cost of purification, evaporation, crystalization, filtration and the like is usually such as to justify the pickler in adopting the cheapest and least objectionable method of disposal.

From the many difficulties encountered in the process of acid pickling comes the incentive to depart completely from the chemical method and to employ the sand blast instead. The operation of this method consists in forcing particles of sand, by means of an air blast, against the surface to be cleaned. The sand quickly breaks up and removes the scale and leaves clean the underlying surface. The only objections to its use is that the expense is greater on account of the increased cost of labor which it involves. However, the use of the sand blast is increasing, and with the improvements in its operation which may confidently be looked for, it is likely to become before long a pronounced competitor of the chemical methods.

It has been known for a long time that hydrogen is readily absorbed by iron under certain circumstances, and that this element has a remarkable influence upon the properties of the iron, which it renders brittle, reducing its strength and elasticity. The hydrogen which is liberated when an iron article is pickled is absorbed to a certain extent by the iron, and this constitutes another one of the many difficulties attendant upon a thoroughly successful pickling operation. An iron or steel wire of high grade may be rendered so brittle by a few moments' immersion in an acid solution as to make it worthless for the purpose for which it was originally intended, so that on account of this "rotting" it is impracticable to pickle certain grades of iron. An investigation of this problem will constitute the subject matter of a subsequent article.

Chemical Engineering Laboratories,
University of Wisconsin,
Madison, Wis.

Metallurgical Calculations.—VIII.

By J. W. Richards, Ph. D.

Professor of Metallurgy in Lehigh University.

THERMO-PHYSICS OF COMPOUNDS.

(Continued.)

There are a few other compounds than those previously mentioned whose thermophysics has been investigated, but their number is in reality infinitesimal compared with the number of those which have not been touched. There are many compounds of great importance in metallurgy whose specific heats are not known, to say nothing of their latent heats of fusion, etc. The wide introduction of the electric furnace has rendered desirable the latent heats of vaporization and specific heats at high temperatures, but these are altogether lacking; we can only estimate their values. It is to be hoped that many metallurgical laboratories may be incited to take up this very neglected field, and thus bring forward numerical data which would be of the greatest theoretical and practical value. One example of such work, which deserves special commendation, is the quite recent publication of Prof. J. H. L. Vogt, of Christiania, on the "Silikatschmelzlösungen," *i. e.*, on "Melted Silicate Solutions," in which determinations of the melting points and latent heats of fusion of many simple and complex silicates are given for the first time; we venture to predict that the data and conclusions of Prof. Vogt will be of great value to the physicist, chemist, metallurgist and geologist, in both a practical as well as a theoretical sense.

In collating the remaining available data, it is rather difficult to decide as to what has immediate metallurgical interest and what has not. Electrometallurgy, in particular, is busying itself with the treatment and decomposition of so many compounds heretofore considered outside of the metallurgists sphere of interest, that almost all of the common chemical compounds now have either a present or a prospective interest to the metallurgist.

Thermophysics of Chlorides.

Hydrogen—HCl (gas) Sm per kilo. (22° — 214°)
= 0.1867 (Regnault)
per m³ (22° — 214°)
= 0.3067 (Regnault)

Lithium—LiCl (solid) Sm per kilo. (13° — 97°)
= 0.2821 Cal. (Regnault)

Carbon—CCl^4 (liq.) L. H. vaporization at 0°
= 52.0 Cal. (Regnault)

Ammonium—NH^4Cl (solid) Sm per kilo. (23° — 100°)
= 0.3908 Cal. (Neumann)

Sodium—NaCl (solid) Sm per kilo. (15° — 98°)
= 0.2140 Cal. (Regnault)

Magnesium—$MgCl^2$ (solid) Sm per kilo. (24° — 100°)
= 0.1946 Cal. (Regnault)

Silicon—$SiCl^4$ (liq.) Sm per kilo. (10° — 15°)
= 0.1904 Cal. (Regnault)
$SiCl^4$ (gas) Sm per kilo. (90° —234°)
= 0.1322 Cal. (Regnault)
$SiCl^4$ (gas) Sm per m³ (90° — 234°)
= 1.0113 Cal. (Regnault)

Potassium—KCl (solid) Sm per kilo. (14° — 99°)
= 0.1730 Cal. (Regnault)

Calcium—$CaCl^2$ (solid) Sm per kilo. (23° — 99°)
= 0.1642 Cal. (Regnault)

Titanium—$TiCl^4$ (solid) Sm per kilo. (13° — 99°)
= 0.1881 Cal. (Regnault)
$TiCl^4$ (gas) Sm per kilo. (163° — 271°)
= 0.1290 Cal. (Regnault)

Chromium—$CrCl^3$ (solid) Sm per kilo. (?)
= 0.1430 Cal. (Kopp)

Manganese—$MnCl^2$ (solid) Sm per kilo. (?)
= 0.1425 Cal. (Regnault)
L. H. vaporization
= 49.37 Cal. (Ogier)

Copper—CuCl (solid) Sm per kilo. (17° — 98°)
= 0.1383 Cal. (Regnault)

Zinc—$ZnCl^2$ (solid) Sm per kilo. (21° — 99°)
= 0.1362 Cal. (Regnault)

Arsenic—$AsCl^3$ (solid) Sm per kilo. (14° — 98°)
= 0.0896 Cal. (Regnault)
(gas) Sm per kilo. (159° — 268°)
= 0.1122 Cal. (Regnault)
L. H. vaporization
= 69.74 Cal. (Regnault)

Strontium—$SrCl^2$ (solid) Sm per kilo. (13° — 98°)
= 0.1199 Cal. (Regnault)

Silver—AgCl (solid) Sm per kilo. (15° — 98°)
= 0.0911 Cal. (Regnault)
(160 °— 380°)
= 0.0978 Cal. (Ehrhardt)

Tin (ous)—$SnCl^2$ (solid) Sm per kilo. (20° — 99°)
= 0.1016 Cal. (Regnault)

Tin (ic)—$SnCl^4$ (liq.) Sm per kilo. (14° — 98°)
= 0.1476 Cal. (Regnault)
(gas) Sm per kilo. (149° — 273°)
= 0.0939 Cal. (Regnault)
L. H. vaporization at 112°
= 46.84 Cal. (Regnault)

Barium—$BaCl^2$ (solid) Sm per kilo. (14° — 98°)
= 0.0896 Cal. (Regnault)

Mercurous—HgCl (solid) Sm per kilo. (7° — 99°)
= 0.0521 Cal. (Regnault)

Mercuric—$HgCl^2$ (solid) Sm per kilo. (13° — 98°)
= 0.0689 Cal. (Regnault)

Lead—$PbCl^2$ (solid) Sm per kilo. (20° — 100°)
= 0.0651 Cal. (Luginin)
(160° — 380°)
= 0.0707 Cal. (Ehrhardt)
(liq.) Sm per kilo. above 485°
= 0.1035 Cal. (Ehrhardt)
L. H. fusion at 485°
= 20.90 Cal. (Ehrhardt)

Thermophysics of Bromides.

Hydrogen—HBr (gas) Sm per kilo. (11° — 100°)
= 0.0820 Cal. (Strecker)
Sm per m³ (11° — 100°)
= 0.2989 Cal. (Strecker)

Sodium—NaBr Sm per kilo. (?)
= 0.1384 Cal. (Regnault)

Potassium—KBr (solid) Sm per kilo. (16° — 98°)
= 0.1132 Cal. (Regnault)

Silver—AgBr (solid) Sm per kilo. (15° — 98°)
= 0.0739 Cal. (Regnault)

Lead—$PbBr^2$ (solid) Sm per kilo. (16° — 98°)
= 0.0532 Cal. (Regnault)
(190° — 430°)
= 0.0532 Cal. (Ehrhardt)
L. H. fusion at 490°
= 12.34 Cal. (Ehrhardt)

Thermophysics of Iodides.

Hydrogen—HI (gas) Sm per kilo. (21° — 100°)
= 0.0550 Cal. (Strecker)
Sm per m³ (21° — 100°)
= 0.3168 Cal. (Strecker)

Sodium—NaI (solid) Sm per kilo. (16° — 99°)
= 0.0868 Cal. (Regnault)

Potassium—KI (solid) Sm per kilo. (20° — 99°)
= 0.0819 Cal. (Regnault)

Cuprous—CuI (solid) Sm per kilo. (18° — 99°)
= 0.0687 Cal. (Regnault)

Silver—AgI (solid) Sm per kilo. (15° — 264°)
= 0.0577 Cal. (Bellati and Romanese)
Mercurous—HgI (solid) Sm per kilo. (17° — 99°)
=0.0395 Cal. (Regnault)
Mercuric—HgI^2 (solid) Sm per kilo. (18° — 99°)
=0.0420 Cal. (Regnault)
Lead—PbI^2 (solid) Sm per kilo. (14° — 98°)
=0.0427 (Cal. (Regnault)
(160° — 315°) =0.0430 (Cal. (Ehrhardt)
(liq.) above 375° =0.0645 Cal. (Ehrhardt)
L. H. fusion at 375° =11.50 Cal. (Ehrhardt)

THERMOPHYSICS OF FLUORIDES.

Sodium-Aluminium—3NaF. AlF^3 Sm per kilo. (16° — 99°)
(Cryolite) =0.2522 (Oeberg)
Calcium (Fluorspar)—CaF^2 Sm per kilo. (15° — 99°)
=0.2154 (Regnault)

THERMOPHYSICS OF SULPHATE.

Hydrogen—H^2SO^4 Sm per kilo. (5° — 22°)
=0.332 (Cattanes)
L. H. vaporization at 326°
=122.1 Cal. (Person)
Sodium—Na^2SO^4 Sm per kilo. (17° — 98°)
=0.2312 (Regnault)
Magnesium—$MgSO^4$ Sm per kilo. (25° — 100°)
=0.2250 (Pape)
Potassium—K^2SO^4 Sm per kilo. (15° — 98°)
=0.1901 (Regnault)
$KHSO^4$ Sm per kilo. (19° — 51°)
=0.2440 (Kapp)
Calcium—$CaSO^4$ Sm per kilo. (13° — 98°)
=0.1965 (Regnault)
Manganese—$MnSO^4$ Sm per kilo. (21° — 100°)
=0.1820 (Pape)
Nickel—$NiSO^4$ Sm per kilo. (15° — 100°)
=0.2160 (Pape)
Copper—$CuSO^4$ Sm per kilo. (23° — 100°)
=0.1840 (Pape)
Zinc—$ZnSO^4$ Sm per kilo. (22° — 100°)
=0.1740 (Pape)
Strontium—$SrSO^4$ Sm per kilo. (2²° — 99°)
=0.1428 (Regnault)
Barium—$BaSO^4$ Sm per kilo. (10° — 98°)
=0.1128 (Regnault)
Lead—$PbSO^4$ Sm per kilo. (20° — 99°)
=0.0872 (Regnault)

THERMOPHYSICS OF NITRATES.

Hydrogen—HNO^3 L. H. vaporization at 326°
=115.1 Cal. (Person)
Ammonium—NH^4NO^3 Sm per kilo. (14° — 31°)
=0.4550 (Kopp)
Sodium—$NaNO^3$ Sm per kilo. (14° — 98°)
=0.2782 (Regnault)
$NaNO^3$ (fluid) Sm per kilo. (320° — 430°)
=0.4130 (Person)
$NaNO^3$ L. H. fusion at 305.5°
=64.87 Cal. (Person)
Potassium—KNO^3 Sm per kilo. (13° — 98°)
=0.2387 (Regnault)
KNO^3 (fluid) Sm per kilo. (350° — 435°)
=0.3319 (Person)
KNO^3 L. H. fusion at 333.5°
=48.90 Cal. (Person)
Sodium-potassium—$(K_2Na)NO^3$ Sm per kilo. (15° — 100°)
=0.2350 (Person)
Strontium—$Sr(NO^3)^2$ Sm per kilo. (17° — 47°)
=0.1810 (Kopp)
Silver—$AgNO^3$ Sm per kilo. (16° — 99°)
=0.1435 (Regnault)
Barium—$Ba(NO^3)^2$ Sm per kilo. (13° — 98°)
=0.1523 (Regnault)
Lead—$Pb(NO^3)^2$ Sm per kilo. (17° — 100°)
=0.1173 (Neumann)

THERMOPHYSICS OF CARBONATES.

Sodium—Na^2CO^3 Sm per kilo. (16° — 98°)
=0.2728 (Regnault)
Potassium—K^2CO^3 Sm per kilo. (23° — 99°)
=0.2162 (Regnault)
Calcium (calcite)—$CaCO^3$ Sm per kilo. (20° — 100°)
=0.2086 (Regnault)
Calcium (aragonite)—$CaCO^3$ Sm per kilo. (18° — 99°)
=0.2085 (Regnault)
Calcium (marble)—$CaCO^3$ Sm per kilo. (23° — 98°)
=0.2099 (Regnault)
Calcium-magnesium—$CaMg(CO^3)^2$ Sm per kilo. (20° — 100°)
=0.2179 (Regnault)
Magnesium-iron—$Mg^7Fe^2(CO^3)^9$ Sm per kilo. (17° — 100°)
=0.2270 (Neumann)
Iron (siderite)—$FeCO^3$ Sm per kilo. (9° 98°)
=0.1935 (Regnault)
Strontium—$SrCO^3$ Sm per kilo. (8° — 98°)
=0.1475 (Regnault)
Barium—$BaCO^3$ Sm per kilo. (11° — 99°)
=0.1104 (Regnault)
Lead (cerussite)—$PbCO^3$ Sm per kilo. (16° — 47°)
=0.0791 (Kopp)

THERMOPHYSICS OF CHROMATES.

Potassium—K^2CrO^4 Sm per kilo. (19° — 98°)
=0.1851 (Regnault)
Potassium—$K^2Cr^2O^7$ Sm per kilo. (16° — 98°)
=0.1894 (Regnault)
Lead—$PbCrO^4$ Sm per kilo. (19° — 50°)
=0.0900 (Kopp)
(Chromite)—$FeCrO^4$ Sm per kilo. (19° — 50°)
=0.1590 (Kopp)

THERMOPHYSICS OF BORATES.

Sodium—$Na^2B^2O^4$ Sm per kilo. (17° — 97°)
=0.2571 (Regnault)
$Na^2B^4O^7$ Sm per kilo. (16° — 98°)
=0.2382 (Regnault)
Potassium—$K^2B^2O^4$ Sm per kilo. (16° — 98°)
=0.2048 (Regnault)
$K^2B^4O^7$ Sm per kilo. (18° — 99°)
=0.2198 (Regnault)
Lead—PbB^2O^4 Sm per kilo. (15° — 98°)
=0.0905 (Regnault)
PbB^4O^7 Sm per kilo. (16° — 98°)
=0.1141 (Regnault)

THERMOPHYSICS OF PHOSPHATES.

Sodium—$Na^4P^2O^7$ Sm per kilo. (17° — 98°)
=0.2283 (Regnault)
Potassium—$K^4P^2O^7$ Sm per kilo. (17° — 98°)
=0.1901 (Regnault)
Calcium—CaP^2O^6 Sm per kilo. (15° — 98°)
=0.1992 (Regnault)
(Apatete)—$3Ca^3P^2O^8.CaF^2$ Sm per kilo. (15° — 99°)
=0.1903 (Oeberg)
Silver—Ag^3PO^4 Sm per kilo. (19° — 50°)
=0.0898 (Kopp)
Lead—$Pb^2P^2O^7$ Sm per kilo. (11° — 98°)
=0.0821 (Regnault)
Lead—$Pb^3P^2O^8$ Sm per kilo. (11° — 98°)
=0.0798 (Regnault)

THERMOPHYSICS OF ALUMINATES, ETC.

Spinell—$MgAl^2O^4$ Sm per kilo. (15° — 47°)
=0.1940 (Kopp)

Chrysoberyl—$BeAl^2O^4$ Sm per kilo. (0° — 100°)
= 0.2004 (Nillson and Pettersson)

Ilmenite—$FeTiO^3$ Sm per kilo. (15° — 50°)
= 0.177 (Kopp)

Wulfenite—$PbMoO^4$ Sm per kilo. (15° — 50°)
= 0.083 (Kopp)

Scheelite—$CaWO^4$ Sm per kilo. (15° — 50°)
= 0.097 (Kopp)

Wolframite—$Fe(Mn)WO^4$ Sm per kilo. (15° — 50°)
= 0.098 (Kopp)

$KMnO^4$ Sm per kilo. (15° — 50°)
= 0.179 (Kopp)

$KClO^3$ Sm per kilo. (10° — 100°)
= 0.210 (Regnault)

Miscellaneous.

Glass—Ca. K Silicate Sm per kilo. (14° — 99°)
= 0.1977 (Regnault)
Sm per kilo. (0° — 300°)
= 0.190 (Dulong and Petit)

Flint Glass—Sm per kilo. (10° — 50°)
= 0.117 (H. Meyer)

Crown Glass—Sm per kilo. (10° — 50°)
= 0.161 (H. Meyer)

Paraffin—(solid) Sm per kilo. (10° — 15°)
= 0.562 (Battelli)
Sm per kilo. (35° — 40°)
= 0.622 (Battelli)
(fluid) Sm per kilo. (52° — 63°)
= 0.706 (Battelli)

Beeswax—(solid) Sm per kilo. (26° — 42°)
= 0.820 (Person)
Sm per kilo. (42° — 58°)
= 1.720 (Person)
(fluid) Sm per kilo. (65° — 100°)
= 0.499 (Person)

Vulcanite—Sm per kilo. (20° — 100°)
= 0.331 (A. M. Mayer)

Soft Para Rubber—Sm per kilo. (0° — 100°)
= 0.481 (H. Gee and Terry)

Thermophysics of Sulphides.

Hydrogen—H^2S (gas) Sm per kilo. (20° — 206°)
= 0.2451 (Regnault)
Sm per m^3 (20° — 206°)
= 0.3750 Cal. (Regnault)

Carbon—CS^2 (liq.) Sm per kilo. (14° — 29°)
= 0.2468 (Person)
(gas) Sm per kilo. (86° — 190°)
= 0.1596 (Regnault)
Sm per m^3 (86° — 190°)
= 0.5458 (Regnault)
L. H. vaporization at 46°
= 83.8 Cal. (Wirtz)

Manganese—MnS Sm per kilo. (10° — 100°)
= 0.1392 (Sella)

Iron—FeS Sm per kilo. (17° — 98°)
= 0.1357 (Regnault)
(Pyrrhotite) Fe^7S^8 Sm per kilo. (20° — 100°)
= 0.1602 (Regnault)
(Pyrites) FeS^2 Sm per kilo. (19° 98°)
= 0.1301 (Regnault)

Nickel—NiS Sm per kilo. (15° — 98°)
= 0.1281 (Regnault)

Cobalt—CoS Sm per kilo. (15° — 98°)
= 0.1251 (Regnault)

Copper—Cu^2S Sm per kilo. (9° — 97°)
= 0.1212 (Regnault)
Sm per kilo. ($0° — t°$) = 0.1126 + 0.00009t
(Bellati and Lussana)

Zinc—ZnS Sm per kilo. (15° — 98°)
= 0.1230 (Regnault)

Arsenic—AsS Sm per kilo. (20° — 100°)
= 0.1111 (Neumann)
As^2S^3 Sm per kilo. (20° — 100°)
= 0.1132 (Naumann)

Molybdenum—MoS^2 Sm per kilo. (20° — 100°)
= 0.1233 (Regnault)

Silver—Ag^2S Sm per kilo. (7° — 98°)
= 0.0746 (Regnault & Sella)
Sm per kilo. ($0° — t°$)
= 0.0685 + 0.00005t
(Bellati and Lussana)

Tin—SnS Sm per kilo. (13° — 98°)
= 0.0837 (Regnault)
SnS^2 Sm per kilo. (12° — 95°)
= 0.1193 (Regnault)

Antimony—Sb^2S^3 Sm per kilo. (23° — 99°)
= 0.0840 (Regnault)

Mercury—HgS Sm per kilo. (14° — 98°)
= 0.0512 (Regnault)

Lead—PbS Sm per kilo. (16° — 98°)
= 0.0509 (Regnault)

Bismuth—Bi^2S^3 Sm per kilo. (11° — 99°)
= 0.0600 (Regnault)

Thermophysics of Compound Sulphides.

Bornite—Cu^3FeS^3 Sm per kilo. (10° — 100°)
= 0.1177 (Sella)

Chalcopyrite—$CuFeS^2$ Sm per kilo. (14° — 98°)
= 0.1310 (Kopp)

Tetrahedrite—$Cu^4Sb^2S^7$ Sm per kilo. (10° — 100°)
= 0.0987 (Sella)

Bournonite—$PbCuSbS^3$ Sm per kilo. (10° — 100°)
= 0.0730 (Sella)

Mispickel—FeAsS Sm per kilo. (10° — 100°)
= 0.1030 (Sella)

Cobaltite—CoAsS Sm per kilo. (15° — 99°)
= 0.0991 (Sella)

Proustite—Ag^3AsS^3 Sm per kilo. (10° — 100°)
= 0.0807 (Sella)

Pyrargyrite—Ag^3SbS^3 Sm per kilo. (10° — 100°)
= 0.0757 (Sella)

Thermophysics of Arsenides and Antimonides.

Löllingite—$FeAs^2$ Sm per kilo. (10° — 100°)
= 0.864 (Sella)

Smaltite—$CoAs^2$ Sm per kilo. (10° — 100°)
= 0.0830 (Sella)

Domeykite—Cu^3As Sm per kilo. (10° — 100°)
= 0.0949 (Sella)

Dyscrasite—Ag^2Sb Sm per kilo. (10° — 100°)
= 0.0558 (Sella)

Thermophysics of Silicates.

Magnesium (Olivin) Mg^2SiO^4
Sm (100° — 0°) = 0.2200 (Vogt)
Melting point = 1400° (Vogt)
L. H. fusion = 130 Cal. (Vogt)
Q (solid) (0° — 1400°) = 520 Cal. (Vogt)

Magnesium (Enstatite) $MgSiO^3$ (with a little Ca replacing Mg)
Sm (0° — 100°) = 0.206 (Vogt)
Sm (0° — 1200°) = 0.301 (Vogt)
Melting point = 1300 (Vogt)
Q (solid) (0° — 1300°) = 403 Cal. (Vogt)
L. H. fusion = 125 Cal. (Vogt)

Aluminium (Topaz) $Al^2Si(F)O^3$
Sm (12° — 100°) = 0.1997 (Joly)

Aluminium-Beryllium (Beryl) $BeAl^2Si^3O^9$
Sm (12° — 100°) = 0.2066 (Joly)

Potassium-Aluminium (Microcline) $KAlSi_3O_8$ — Triclinic
Sm (20° — 100°) = 0.197 (Bogajawlensky)
Melting point = 1170° (Vogt)
L. H. fusion = 83 Cal. (Vogt)

Potassium-Aluminium (Orthoclase) $KAlSi_3O_8$ — Monoclinic
Sm (20° — 100°) = 0.1877 (Oeberg)
Melting point = 1200° (Vogt)
L. H. fusion = 100 Cal. (Vogt)

Calcium-Aluminium (Anorthite) $CaAl_2Si_2O_8$
Sm (100° — 0°) = 0.189 (Vogt)
Sm (1200° — 0°) = 0.294 (Vogt)
Melting point = 1220° (Vogt)
Q (solid) (0° — 1220°) = 358 Cal. (Vogt)
L. H. fusion = 100 Cal. (Vogt)

Calcium (Wollastonite) $CaSiO_3$
Sm (0° — 100°) = 0.179 (Vogt)
Sm (0° — 1200°) = 0.288 (Vogt)
Melting point = 1250° (Vogt)
Q (solid) (0° — 1250°) = 360 Cal. (Vogt)
L. H. fusion = 100 Cal. (Vogt)

Calcium-Magnesium (Malacolite) $Ca_2MgSi_4O_{12}$
Sm (0° — 100°) = 0.186 (Vogt)
Sm (0° — 1200°) = 0.264 (Vogt)
Melting point = 1200° (Vogt)
Q (solid) (0° — 1200°) = 319 Cal. (Vogt)
L. H. fusion = 94 Cal. (Vogt)

Calcium-Magnesium (Diopside) $CaMgSi_2O_6$
Sm (0° — 100°) = 0.194 (Vogt)
Sm (0° — 1200°) = 0.281 (Vogt)
Melting point = 1225° (Vogt)
Q (solid) (0° — 1225°) = 344 Cal. (Vogt)
L. H. fusion = 100 Cal. (Vogt)

Iron (Fayalite) Fe_2SiO_4
Sm (0° — 100°) = 0.1700 (Vogt)
Q (solid) (0° — 1040°) = 310 Cal. (Vogt)
L. H. fusion = 85 Cal. (Vogt)

Iron-Aluminium (Garnet) $Fe_3Al_2Si_3O_{12}$
Sm (16° — 100°) = 0.1758 (Oeberg)
Melting point = 1145° (Joly)

Zirconium (Zircon) $ZrSiO_4$
Sm (15° — 100°) = 0.1456 (Regnault)
Melting point = 1760° (Joly)

(Pumice) Sm (10° — 100°) = 0.240 (Dunn)

(Lava from Ætna, 1669)
Sm (0° — 500°) = 0.182 + 0.000155t (Bartoli)
Sm (500° — 800°) = 0.270 (Bartoli)

(Crystalline Slag)
Sm (14° — 99°) = 0.1888 (Oeberg)

(Enamel Slag)
Sm (15° — 99°) = 0.1865 (Oeberg)

(Bessemer Slag)
Sm (14° — 99°) = 0.1691 (Oeberg)

(Basalt) Sm (20° — 470°) = 0.1990 (Roberts-Austen)

(Granite) Sm (20° — 524°) = 0.2290 (Bartoli)

For silicates in general, the specific heat is found to agree fairly well with what would be calculated from their percentage composition, giving each oxide constituent its proper specific heat. Those oxides whose specific heat at 0° are known are as follows:

SiO_2 = 0.1833 (Richards)
Al_2O_3 = 0.2081 (Richards)
Fe_2O_3 = 0.1456 (Richards)
MgO = 0.2420 (Regnault)
CaO = 0.1779 (calculated)

Those which are not known give good results if assumed to be as follows:

FeO = 0.1460 (Vogt)
MnO = 0.1511 (Vogt)
K_2O = 0.1390 (Vogt)
Na_2O = 0.2250 (Vogt)
Li_2O = 0.4430 (Vogt)

Using these data, S at 0° is calculated from the percentage composition of the silicate. For S at higher temperatures it can be assumed with considerable approximation to the truth, that S increases 0.078 per cent for each degree, and so, calling S_0 the specific heat at zero, we would have

$S = S_0 (1 + 0.00078t)$
$Sm = S_0 (1 + 0.00039t)$
$Q (0° — t°) = Sm \times t$

Besides the above generalizations, which enable one to calculate the heat in the solid silicate at the melting point (when the latter is known), Vogt has shown that if the heat necessary to heat the silicate from — 273° to the melting point is calculated, the latent heat of fusion may be taken as being 20 to 25 per cent of this quantity, say an average of 22.5 per cent, and thus the heat required for fusion may be approximately calculated.

Akerman has determined for many metallurgical silicate slags the total heat contained per kilogram of melted slag at the melting point. These quantities vary from 347 to 530 Calories, depending principally on the elevation of the melting point of the slag. A brief tabulation of Akerman's results are as follows, arranged according to the amount of heat in the just-melted slag:

Calories.	%SiO_2	%CaO	%Al_2O_3
347	59	36	5
	39	42	19
350	63	35	2
	58	35	7
	58	37	5
	53	37	10
	41	42	17
	38	47	15
	39	43	19
	37	40	23
360	66	32	2
	59	38	3
	48	42	10
	40	48	12
	34	48	18
	31	37	32
	46	37	17
	58	32	10
380	58	27	15
	62	37	1
	38	52	10
	25	34	41
	44	33	23
400	60	20	20
	65	35	0
	41	52	7
	37	53	10
	21	32	47
	43	30	27

The above includes most varieties of acid and basic iron blast-furnace slags. Data for other slags made in the metallurgy of iron and of other metals, are almost altogether lacking. A wide field is here open for metallurgical experiments; data thus obtained would be immediately useful in practical calculations.

[On account of absence of the writer from the United States the foregoing instalment is shorter than usual and problems are lacking. The brevity and omissions will be compensated for in following instalments.]

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

Electric Furnaces.

Incandescent Electric Furnace.—F. J. Tone, 800,515, Sept. 26. Application filed Dec. 7, 1904.

In intermittently-operating resistance furnaces, as used for the production of carborundum, siloxicon and graphite and for heating carbon articles, the charge is piled up within walls of loose bricks. These walls serve merely to keep the charge in position, and being protected from the heat by the charge material they need not be highly refractory. After each furnace run the walls are removed, either wholly or in part, and up to the present the walls have been torn down by hand-labor, one brick at a time, and built up in the same manner. To save this expense, the inventor uses permanent end walls, which support the electrodes and make the side walls of one or more sections composed of reinforcing frames of iron, in which the walls are assembled. This renders the walls permanent in character and movable by means of cranes. The frames are constructed with downwardly-converging sides. This is important in a carborundum furnace, because it saves charge mixture.

Revolving Electric Furnace.—E. Stassano, 799,105, Sept. 12. Application filed April 9, 1902.

Claim 1 reads: "In an electric furnace, the combination with a circular closed chamber having its axis inclined at an angle to the vertical, of means for rotating such chamber, means for feeding an anode and a cathode toward one another within the chamber, and means for cooling the outer ends of the anode and cathode." Two vertical sections through the furnace are shown in Fig. 1.

This is the steel furnace used in the Government Gun

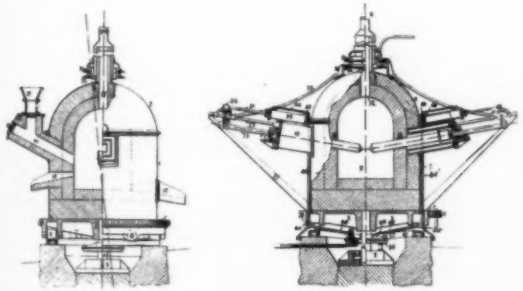

FIG. 1.—STASSANO STEEL FURNACE.

Foundry in Turin, Italy, described in the Canadian Commission report (page 11) as follows: "The rotation of the furnace during the operation produces a proper intermixture of the melting mass, which, according to the inventor, results in accelerating reduction 'with great advantages from the point of view of the utilization of the heat and the preservation of the fireproof lining of the furnace.' * * * The furnace is of the arc type and consists of a cylindrical outer casing of iron, surmounted by a conical roof. The furnace is lined with magnesite brick. The axis of the furnace about which it rotates during the operation, includes an angle of 7° with the vertical. A three-phase alternating current of 90 volts between the phases and 400 amps. is distributed to the three electrodes, which nearly meet in the center of the interior of the furnace. Their distance apart is varied by a hydraulic regulator." Data on cost of furnace and operation are also given in the Canadian Commission report.

According to recent reports the Forni Termoelettrici Stassano Co. has been formed in Turin for the manufacture of steel in the Stassano furnace. Two furnaces, one of 1000 hp. and one of 200 hp., are to be installed.

Purifying Tantalum.—Werner von Bolton. (Assigned to Siemens & Halske, A. G.) 799,441, Sept. 12. Application filed Oct. 12, 1904.

Tantalum is freed from impurities, especially from tantalum oxide, by heating in an electric furnace in a vacuum. The oxide is sooner volatilized than the tantalum metal itself. The process is possibly aided by an electrolytic or thermic decomposition of the oxide into metal and oxygen. A vacuum is required, since at the very high temperature the tantalum metal is liable to enter into reaction with nearly all known elements. An arc furnace is used with electrodes of tantalum; or the arc is produced between the mass, to be purified, and one electrode of tantalum.

Producing Alkali and Alkaline-Earth Metal Hydrides.—F. J. Machalske, 800,380, Sept. 26. Application filed July 12.

A compound of an alkali or an alkaline-earth metal; for example, an oxide, carbonate, chloride, sulphate, sulphide, carbide or cyanamide, or a mixture of two or more of these compounds is heated to a high temperature in an electric furnace and is then subjected to the action of a saturated hydrocarbon, specifically methane or natural gas, thereby producing a hydride of the metal and by-products dependent on the compound employed. For instance, when calcium oxide and methane are the reacting compounds the products are calcium hydride, carbon monoxide and hydrogen. When chlorides of the metals are used, the chlorine combines with the carbon of the methane to produce chlorides of carbon.

Metallurgical Furnace.—G. H. Benjamin, 798,258, Aug. 29. Application filed April 25, 1903.

Details of construction of a tank-furnace, specially adapted to glass manufacture. ("It may, however, be used in smelting ores to obtain matte or pig metal and in other corresponding metallurgical operations.") Fig. 2 shows the furnace with the circular tank at the bottom. Extending from one side of the tank, and in an upward direction, is a flue in form of a series of communicating inclined and vertical passages. Each vertical passage is divided into two compartments, the outer one forming a by-path for the products of combustion, which flow to the chimney flue, while the inner compartment forms the connection between two succeeding inclined passages. This inner compartment contains the electrodes for the arcs (indicated in Fig. 2 in cross-section by small circles.) The glass-making materials drop down through the arcs, and are acted upon by the same. Sand is fed into the furnace through the hopper at the top and passes downward through the flue. Just before it reaches a vertical passage, fluxes, lime, etc., are fed through the hoppers, specially provided for this purpose, as shown in the illustration. The mixture then drops downward through the

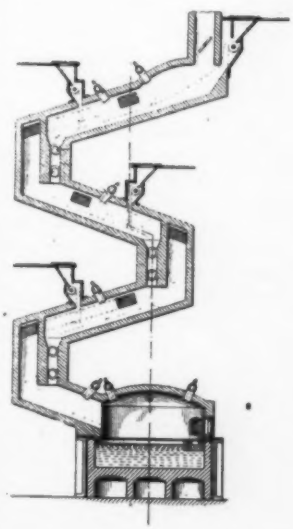

FIG. 2.—GLASS FURNACE.

arcs. On account of the provision of the outer compartments of the vertical passages, which form a by-path for the products of combustion, the light materials in the form of fluxes are not subjected at the time of their introduction into the furnace to the carrying action of flames or air currents.

Electrolysis.

Electrolytic Process.—Carl Hering, 798,790, Sept. 5. Application filed July 13, 1901.

Any electrolytic action disturbs the equilibrium which existed before in the electrolyte. In many cases the products of electrolytic action pass into or combine with the electrolyte and then participate in the conduction of the current; this may result in undesired reactions. To prevent such "objectionable" ingredients from accumulating in the electrolyte, the inventor catches the ions which would produce them at the electrodes in form of an insoluble compound. It may be that the ingredients would be objectionable in the electrolyte, but otherwise valuable. In such cases the electrode, which has now on its surface the insoluble compound, is removed from the electrolytic cell and placed into another cell, and the current is now passed through the electrode in the reverse direction; *i. e.*, if the electrode was before anode, it is now made cathode, and reversely. The result is, of course, that the insoluble compound is decomposed and the ingredient is obtained in the new cell in which it is no longer objectionable. The process will be rendered clear by two examples:

If zinc is extracted from an aqueous solution of zinc sulphate, with an inert anode, the anodic reaction is the evolution of oxygen and formation of sulphuric acid. Here the accumulation of sulphuric acid becomes objectionable, since it participates in the conduction of the current with resulting evolutions of hydrogen at the cathode and a correspondingly decreased efficiency of zinc deposition. Therefore, the SO_4 anion is not allowed to form sulphuric acid at the anode, but is caught in form of an insoluble sulphate. This may be done by means of a spongy lead plate (as used in storage batteries), where lead sulphate is formed. Under such conditions zinc may be deposited on the cathode without evolution of hydrogen, *i. e.*, with a high efficiency. If the lead plate with its coating of lead sulphate is then removed from the cell and used in another cell as cathode, it changes back into spongy lead, and gives off sulphuric acid.

Another example is the recovery of both zinc and acid from discharged primary-battery cells. First, the free acid is extracted by electrolyzing the solution between a spongy lead anode and lead peroxide cathode; both electrodes then receive a coating of lead sulphate; they are then removed and changed back in another cell to recover the acid. The solution from the first cell is then electrolyzed between a cathode of mercury, zinc amalgam, etc., and a spongy lead anode, as in the first example.

Ferric Oxide Electrodes for Chloride Electrolysis.—H. Specketer, 800,181, Sept. 26. (Assigned to Chem. Fabrik Griesheim Elektron.) Application filed Feb. 18, 1903.

A method of producing "in any large quantity good and useful magnetic oxide-of-iron electrodes of good electrical conductivity and great resistance against chemical action." The inventor uses "ordinary oxide of iron, such as is found, for example, in the decopperized pyritic waste (purple ore), in unlimited quantities and in the necessary purity at an exceedingly low price." The description of the method is very meager. The bottom of the electric furnace for smelting the mass is connected with the positive pole of the electric supply circuit. Above it is provided a movable vertical rod of carbon, connected to the negative pole of the supply circuit. The molten mass flows from the furnace through a channel in the wall into a properly shaped mould.

The properties claimed for this electrode are of considerable interest. They are "particularly suitable for the electrolysis of chlorides of alkalies, and present the following advantages over the hitherto-used anodes of carbon and platinum: First, they are considerably cheaper, their price being about a fifth of that of the carbon anodes, and they have an unlimited life in comparison with the latter; second, they furnish the chlorine free of carbonic acid, which is of great value for the manufacture of bleaching powder, for the volatilization of the chlorine, and for other uses of the chlorine, and, third, they require a considerably lower tension of the current than the electrodes of platinum."

Electrolytic Apparatus and Electrodes Therefor.—Carl Kellner, 799,061, Sept. 12. Application filed July 7, 1896.

In conducting an electrolytic process at high-current density with electrodes of an expansive material, like platinum, the cost sometimes becomes prohibitive with solid-plate electrodes. "A current from solid-plate electrodes will either be of insufficient density for the purpose or uncontrollable." Moreover, the large surface of a solid-plate electrode may have the disadvantage of unduly accelerating undesirable secondary reactions (for instance, in the electrolysis of sodium chloride for the production of bleaching liquor, those particles of hypochloride formed which come into contact with the cathode, are reduced again to chloride). The inventor uses for such purposes an electrode, consisting of a plate of non-conducting material, like glass or ebonite, around which is wound a helix of wire of platinum, etc. This may be used as a bipolar electrode, so that any number of such plates may be placed one after the other in a cell.

Electrolytic Reduction of Oxalic Acid.—E. von Portheim, 798,920, Sept. 5. Application filed Jan. 29, 1904.

A method of obtaining glyoxalic acid, its esters and anids, from compounds containing the radical oxayl (C_2O_2), consisting in dissolving the compound to be treated in dilute sulphuric acid in the cathode compartment of an electrolytic cell, and then electrolyzing the solution at a low or moderate temperature. For instance, in a diaphragm cell containing 2½ per cent sulphuric acid, oxalic acid is dissolved in the solution in the cathode compartment. Electrolysis is started, and by titration with a solution of phenylhydrazine the increment of glyoxalic acid is ascertained. When the maximum is reached, or just overpassed, the electrolysis is interrupted. The solution of glyoxalic acid is freed from the remaining small quantities of sulphuric acid by barium hydrate, and retains no impurities, with the exception of a slight trace of glycolic acid.

Electrolytic Production of Metallic Wire, Strip, etc.—S. O. Cowper-Coles, 799,634, Sept. 19. Application filed Feb. 6, 1905.

Around the periphery of a mandrel or cathode, which is preferably cylindrical, a fine groove or indentation of V-shape is described in the form of a helix or spiral, the pitch of which depends upon the width of the rod or tape to be produced. The groove must be very fine. The mandrel is rotated at a high speed. When the desired thickness of metal has been deposited upon the mandrel in the usual way, the latter is removed from the vat, when it is found that the metal sheet can be wound off from the mandrel with facility in the form of a spiral, the metal parting along the line of the groove or indentation."

Electrotyping.—C. F. Blackledge, 799,218, Sept. 12. Application filed Jan. 14, 1905.

The object is to quickly precipitate a compact and uniform surface of metallic silver upon a wax mould, so as to make it a conductor for subsequent deposition of nickel for electrotyping purposes. Twenty grains of nitrate of silver are added to 1 ounce of water, and liquid ammonia is added until the precipitate is redissolved. A reducing agent is then prepared, consisting of 40 per cent formaldehyde diluted with water in the proportion of 1 ounce of the former to 3 ounces of the latter. An alcoholic substratum of collodion is then applied to the wax mould with a brush or by flowing over it; it is made by dissolving 1 grain of gun-cotton in ¼ ounce of sulphuric

ether and ¾ ounce of 95 per cent alcohol. Now, the above reducing agent is added to the silver solution in the proportion of 6 drams of the former to 2 ounces of the latter, and immediately afterwards the mixture is poured on the face of the mould, and the mould is manipulated so that the mixture is spread evenly over the face. In a very short time the mould gets a compact silver surface, on which nickel may be easily precipitated.

Electroplating Apparatus.—Louis Potthoff, 799,402, Sept. 12. Application filed April 30, 1904.

Details of apparatus for galvanizing bars, tubes and other pieces too large to be shaken up, as is done with small nails, etc. The inventor provides a traveling band with a series of cathode terminals adapted to move the articles to be galvanized; he also provides means which will automatically change the point of contact between the articles, the supporting means and the cathode terminals.

Galvanizing Wire.—G. L. Meaker, 799,860 and 799,861, Sept. 19. (Assigned to American Steel & Wire Co., of New Jersey.) Application filed Feb. 1, 1905.

A method and details of apparatus for coating a wire with zinc. The wires are laid in place from above, both the anode and the cathode contacts being slotted, or opened upwardly to receive the wire. The inventor also has devised a contact for the wire comprising a receptacle containing a series of loose balls, among which the wire may be readily placed, and, while making a good contact with the wire, the balls will yield to allow a joint in the wire to freely pass through without breaking the electrical connection. A cap or casing of insulating material is provided for each anode, so as to guide the wire and prevent it from short circuiting by coming into contact with the anode.

Electrode of Electrolytic Apparatus.—G. J. Atkins, 798,314, Aug. 29. Application filed Nov. 22, 1904.

Details of construction of a drum, almost completely closed, with the exception of a slit in the top; its inner surface is lined with carbon, which forms the anode; it is constructed in two symmetrical parts so that the drum may be opened and the cathode inserted or removed. The cathode is of cylinder form, concentric with the drum, and provision is made for revolving the cathode.

Batteries.

Storage Battery.—A. E. Knight, 798,906, Sept. 5. Application filed Nov. 16, 1904.

Details of construction for the purpose of preventing the buckling of the positive plates of storage batteries. The plate is provided with a plurality of slots, which extend from one side toward but not to the opposite side, so that the latter is composed of an unslotted portion from which extend a plurality of arms. These arms have coöperating with them a guide extended transversely of the arms and causing the arms to expand in a straight path.

Grid.—W. Gardiner, 800,128, Sept. 19. (Assigned to Universal Electric Storage Battery Co.) Application filed Aug. 22, 1904.

A sheet of pure lead is rolled into very thin sheets and closely perforated; it is then folded transversely into a plurality of folds. The outer edges are forced close together, leaving the central portion of the fold curved outwardly. The plate is then formed electrochemically.

Miscellaneous.

Electrolyzing Air.—A. Johnson, 798,511, Aug. 29. (Assigned to Barnard & Leas Mfg. Co.) Application filed Jan. 5, 1905.

The object is to convert air into a gaseous medium for bleaching flour by electric arc discharges. The apparatus consists of a number of tubular "generating chambers" in which the arc discharges take place between an upper cylindrical negative and a lower globular positive electrode. The position of the upper electrode can be adjusted so as to regulate the arc discharge. The amount of air passed through these chambers is controlled by valves. The outlet valve is automatically closed when the electrodes are in contact and is opened when the electrodes are separated.

Liquid Heater and Strainer.—W. J. Morrison, 799,798, Sept. 19. Application filed Nov. 7, 1904.

In obtaining certain liquids it is desirable that they be heated to a certain temperature as they are passing through the strainer. The inventor provides a form of strainer made up of a series of contiguously arranged sections of non-absorbent material, in which a suitably controlled electrically-heated conductor is embedded.

RECENT METALLURGICAL PATENTS.

On account of space limitations, due to the report of the American Electrochemical Society meeting, a large number of abstracts of metallurgical patents had to be reserved for our next issue.

Antimony.

J. S. MacArthur (796,849, Aug. 8) patents a process for the recovery of antimony compounds from ores containing them (especially stibnite Sb_2S_3) and the regeneration of the chemicals employed. A solution of 2 per cent of caustic soda is prepared in a causticizing vat provided with an agitator and a steam-jacket or coil, and is then delivered to a storage vat, also provided with a steam-jacket or coil, in which its temperature is maintained at about 100° C. The heated solution is then led to extraction vats provided with agitators, and it may be with steam-jackets or coils. The antimonial ore in a state of comparatively fine division—such, say, as to pass through a sieve of twenty meshes per linear inch—is introduced into the extraction vats, and the heated alkali solution is then allowed to act upon it, either at one or in successive operations, taking into solution practically its whole antimonial contents. The solution is then pumped from the extraction vats to a filter press, the effluent from which passes to precipitation vats. In the precipitation vats the antimony is precipitated from the solution and carbonate of soda formed in it by carbonic acid gas passed into the solution by distributing devices, the carbonic acid gas being preferably obtained from lime kiln or furnace gases. The solution is cooled while in the precipitation vats. The antimonial magma from the precipitation vats is discharged to a filter press, the effluent carbonate of soda solution from which is delivered to sumps, while the recovered antimony compound is removed from the filter press in the usual cake form. The carbonate of soda solution is delivered from the sumps back to the causticizing vat, and caustic soda is reformed by a suitable causticizer, preferably lime obtained from the kiln supplying the carbonic acid gas. The process thus proceeds in a cycle, the alkaline solution first acting on the ore, then being formed into a carbonate and then recausticized repeatedly.

Filter.

G. A. Duncan patents two filter constructions. The essential feature of one patent (796,198, Aug. 1) is a filtering bag of canvas, stretched upon and enclosing a peripheral frame made of perforated pipe. The pipe frame has connections extending fluid-tight through the web for exterior communication. The second patent (796,503, Aug. 8) relates to a filtering cell with its length and breadth respectively horizontal and vertical, while its thickness is small compared with the other dimensions. This filtering cell is suspended in a tank of similar proportions, there being relatively small space at opposite sides of the cell. Suction pipes intrude into the cell from the top and terminate open near the bottom. The slime-bearing liquor is supplied to the tank and aerated from the bottom.

Furnace Construction.

The ore roasting furnace of H. C. Holthoff (797,003, Aug. 15) has already been introduced into metallurgical practice by the Power & Mining Machinery Co., and was described in detail on page 87 of our February issue.

A patent of W. T. Rushton (797,915, Aug. 22) relates to mechanical details of a roasting furnace comprising one or more cylindrical muffles with internal spiral flanges, whereby the material under treatment is conveyed from end to end of the cylinder as the latter rotates. Cross projections, or inclined baffles, are arranged between adjacent flanges, and project laterally therefrom, so as to assist in moving the material.

J. A. Anker, J. H. Watson and P. Evans (794,837, July 18) patent a sinuous vertical roasting chamber; from the convexed portions of the walls project retaining shoes which catch a falling stream of ore, and retain the same in a mass and then delivers the mass gradually in a thin stream. These shoes are arranged in two sets, and automatically one set is brought to a horizontal position while simultaneously the shoes of the other set are inclined. Oil burners project their flame underneath the shoes, and independently of, but in proximity to burner, an air blast is introduced into the chamber.

A patent of C. E. Keating (797,584, Aug. 22) refers to details of construction of conveyor mechanism by which ore is moved along the hearth of a roasting furnace. A conveyor extends along the hearth from end to end and carries a succession of alternate sets of relatively fixed and rotating stirring devices. The fixed devices are adapted to enter the mass of material resting on the hearth and turn the same into longitudinal furrows, while the rotating devices have arms, entering the mass of material and rolling in a longitudinal direction, for preventing a crust from forming on the surface of the material.

F. Baldt (797,883 and 797,932, Aug. 22) patents details of construction by which open-hearth furnaces may be conveniently cleaned of any deposit which settles therein.

C. Ellis (795,259, July 18) points out that in present gas regenerative furnaces employing the usual type of reversing regenerator, the sensible heat of the producer gas is from the nature of the system employed wholly wasted. His invention consists of a furnace having an auxiliary or third regenerator, through which the air for combustion travels before entering the air regenerator proper, and which on the reversal is so constructed that the products of combustion from both the air and producer-gas regenerators combine and pass through this auxiliary checker-work, thereby giving up an additional portion of their sensible heat before departing to the stack passage. As this auxiliary regenerator has been cooled by the entering air to a low temperature much lower than that of the producer gas, it follows that the sensible heat of the producer gas, or a large portion thereof, is conserved and utilized.

J. Kirby (793,938, July 4) patents details of construction of a furnace in which the ore is to be smelted and refined by one and the same fire. It is a reverberatory furnace with an inclined smelting hearth. The molten mass then passes into a basin where it is refined.

A. Skoog (783,903, February 28) patents details of construction of an upright furnace for roasting quicksilver ores. By means of a plurality of fire and ore chambers arranged alternately and having them comparatively long and flat, with sinuous windings of the heat and vapors, the heat acts on the ore from all sides.

SYNOPSIS OF PERIODICAL LITERATURE.

A Summary of Articles Appearing in American and Foreign Periodicals.

Industrial Electrochemistry.

Aluminium Industry.—The *United States Geological Survey* has just published the statistics of the production of aluminium and bauxite in 1904. The production in this country has increased about tenfold in as many years. The following table shows the development in the United States since 1883, the output being given in pounds:

1883, 83 pounds; 1886, 3000; 1892, 259,885; 1896, 1,300,000; 1900, 7,150,000; 1904, 8,600,000.

The world's production in 1903 was as follows:

	Metric Tons.	
United States	3,402	$2,325,000
Switzerland	2,500	1,413,125
France	1,700	849,025
United Kingdom	650	328,250
Total	8,250	$4,915,400

A new development of some interest is the attempt to utilize the extensive deposits of bauxite at Leece, Italy, and the waterfalls of Pescara to generate electric power for the purpose of manufacturing aluminium. The prices per pound of aluminium and its alloys in 1901, 1902, 1903 and 1904 were as follows:

	Small lots. Cents.	100 lb. Lots.	1000 lb. Lots.	2000 lb. Lots.
No. 1, aluminium, 99.75%	37	35	34	33
No. 2, aluminium, 90%	34	33	32	31
Nickel-aluminium casting metal (10% Ni)	39	35	34	33
Special casting alloy (80% Al)	35	30	29	27

Aside from the electrical industry in which aluminium is gaining favor as a substitute for copper conductors for transmission lines, there has been expansion in other directions. "The steel industry has become an important consumer of aluminium. Usually from 2 to 5 ounces of aluminium are employed per ton of open-hearth steel made, and from 6 to 8 ounces for Bessemer steel." If every ton of steel manufactured in the United States in 1904 had been subjected to this treatment, there would have been something like 5,000,000 pounds of aluminium consumed. "The consumption of thermit shows marked expansion. * * * For welding iron and steel and for reducing refractory oxides thermit has no equal." Aluminium alloys represent a fertile field for inventors. The production of bauxite in the United States in 1904 amounted to 47,661 long tons, valued at $235,704.

Sterilization of Water by Ozone.—The August issue of the *Bulletin Mensuel* of the Société Belge d'Electriciens contains an illustrated paper by L. Gerard on the use of electric power in connection with the water-works of Breda, Netherlands. Alternating current is taken from the lighting network, which is operated by the three-wire system of 100 volts between each outer and the neutral wire. The water-works treat 20 cubic meters of water per hour. The water first undergoes rapid sand filtration and is then sterilized by ozone. For the operation of the ozonizers the voltage is raised from 100 to 65,000. The Schueller ozonizer is used, which is very briefly described. The average production of ozone is 7 grams per kw-hour. Considerable data are given as to the sterilizing effect of ozone upon water and the cost of operation. The cost of the production of the ozone and of its use for the sterilization of water, together with the cost of the previous filtration, is stated to be 1 cent per cubic meter; of this amount 0.234 cent

is the cost of the ozone and 0.76 general expenses, interest on capital and amortization. The paper contains considerable statistical information.

Electric Steel Furnaces.—The *Oest. Zeit. f. Berg u. Hüttenwesen*, No. 31 to 36 (Aug. 5 to Sept. 9), contains a long illustrated serial, by Viktor Engelhardt, on the use of the electric furnace in the metallurgy of iron and steel. He first gives a general review of the subject and then discusses in detail the Kjellin furnace; the information appears to be the same as in his former paper (see page 294 of our August issue).

THEORETICAL AND EXPERIMENTAL.

Tantalum and Columbium.—In view of the increased importance of tantalum, due to the new tantalum lamp, two papers from the John Harrison Laboratory of Chemistry of the University of Pennsylvania are quite interesting, giving new information on the chemistry of these elements. Both papers are printed in the *Proc. Am. Phil. Soc'y*, Vol. 44. 1905, on pages 151 and 177, respectively; Edgar F. Smith being the author of one paper, and the same and Roy D. Hall joint authors of the other. Without going into details it may be said that they succeeded in preparing large quantities of the double fluoride of tantalum and potassium, and had no difficulty in eliminating from it every trace of what was supposed to be the titanium double fluoride. Having thus at their disposal really pure tantalic oxide, it was determined to make a new study of the double fluorides of tantalum with the alkali metals and organic bases. One interesting result is that there are two cæsium tantalum fluorides, two rubidium tantalum fluorides, two sodium tantalum fluorides, two ammonium tantalum fluorides, etc.

Electroanalysis.—A paper by Lily G. Kollock and Edgar F. Smith, in Vol. XLIV. (1905), p. 137, of the *Proc. Am. Phil. Soc'y*, recommends the combined cury cathode for electroanalytic use of a rotary anode and a merwork. Not only is the time reduced for the precipitation of the metals which were studied, but "the plan of combining a mercury cathode with the rotating anode gives an inexpensive form of apparatus which will eliminate the platinum dish, cone or cylinder from electroanalysis, and thus remove an expensive factor." Fig. 1 gives the results of the precipitation of zinc from zinc sulphate (containing 0.2025 gr. zinc with some free sulphuric acid); the current was 2 amps., the voltage 7, the speed of anode 500 r. p. m. The deposition was complete in 15 minutes. The absissas in Fig. 1 represent the time, the ordinates the weight of zinc deposited at the corresponding moment. Other metals studied were copper, nickel, cobalt, chromium and iron.

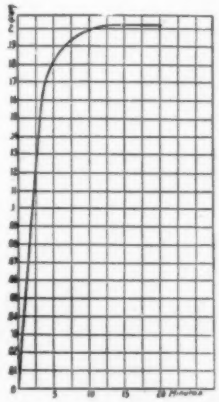

FIG. 1.—ELECTROANALYSIS.

Physico-Chemical Research in Japan.—Vol. I., No. 2 of the *Memoirs* of the College of Science and Engineering of Kyoto Imperial University, contains three papers by Yukichi Osaka; the first relating to the distribution of iodine between two solvents, the second to the equilibrium of the electrolytic dissociation of partial neutralized acids and gases, and the third to the reaction between silver nitrate and disodium phosphate. The same journal contains an article by Sadajiro Okada, on the action of phosphorus pentachloride upon dextro-tartarin.

Electrolytic Analysis of Antimony.—This is the subject of a paper by H. D. Low and F. Mollwo Perkin, presented before the Faraday Society on July 3. Owing to the trouble of preparing the sodium sulphide solutions necessary for electrolysing antimony solutions by the method of Classen, the authors recommend the use of a solution containing ammonium tartrate, which they have found to give very satisfactory results. J. H. Belcher said that he had used the ammonium tartrate solution with success.

Hydrate Theory of Solutions.—A very interesting paper on an application to electrolytes of the hydrate theory of solutions was presented on May 18 before the *Faraday Society*, by T. Martin Lowry. The object of the paper is to consider the possibility of extending the hydrate theory to electrolytes in such a way as to take account of the observations which form the experimental basis of the theory of electrolytic dissociation. The hydrate theory postulates that an aqueous salt solution consists of a mixture of hydrates in equilibrium with the solvent and with one another. But it must be supposed that even in solution there is a limit to the possibility of hydrate formation, so that ultimately a stage will be reached at which the molecule as such will be unable to combine with any further quantity of water. The ionization of an aqueous electrolyte consists essentially in a further process of hydration, whereby the fully hydrated molecule combines with an additional quantity of water to form two or more hydrated ions. The hydration of the ions is thus conceived to be the primary cause of the ionization of aqueous electrolytes. It is believed that this extension of the hydrate theory to the phenomena of electrolysis may help to remove the fundamental difficulty of Arrhenius's theory, namely, the absence of a motive for electrolytic dissociation. The author discusses in detail various facts which are in favor of his hypothesis, and thinks the latter is quite as simple as the dissociation theory. For any given solution the chief constants are: (1) The total hydration H, of the solution, which expresses the total number of molecules of water present per molecule of salt. (2) The coefficient of combination b which expresses the fraction of the total quantity of water that is actually combined with the salt to form hydrates. (3) The product of these two quantities will give the average composition of the hydrates in solution; this may be termed the "molecular hydration" of the solution, and may be represented by the symbol h. Thus $h = b\,H$ may be regarded as the fundamental equation of the hydrate theory.

Dissociation.—Two papers on the dissociation of ternary electrolytes, by K. Drucker and G. Kuemmell, are published in *Zeit. f. Elektrochemie*, April 7 and June 2, respectively. The dissociation of potassium iodine is a subject of a discussion by J. W. McBain in *Zeit. f. Elektrochemie*, April 7. This paper is interesting, since it refers to the former method of procedure of theorists in the dissociation theory. Formerly one used to assume that the molecule dissociates into certain ions, and to test whether the conclusions are correct. The present author uses all the facts established experimentlly concerning transport numbers, electric conductivity and depression of the freezing point, to determine the concentrations of all the ions and complex ions which are theoretically possible. C. Liebenow, in *Zeit. f. Elektrochemie*, May 26, publishes a highly theoretical and mathematical paper, in which he develops a new formula for the dissociation of electrolytes, which he shows to be in agreement with Kohlrausch's measurements.

Equilibrium Conditions.—A paper by R. Luther and G. V. Sammet, in *Zeit. f. Elektrochemie*, May 19, deals with the conditions of equilibrium of the following two reactions:

$$HIO_3 + 5HI \rightleftarrows 3I_2 + 3H_2O$$
$$HBrO_3 + 5HBr \rightleftarrows 3Br_2 + 3H_2O$$

as determined chemically and by e.m.f's.

Tantalum.—F. Streintz in *Zeit. f. Elektrochemie* makes some remarks concerning Bolton's determinations of some properties of metallic tantalum. He compares the temperature coefficient as determined by Bolton with those of some other metals, and finds the rule confirmed, that with increasing

atomic weight the temperature coefficient of the resistance increases.

Silicon.—Some rather peculiar notes on silicon are given by T. Gross in *Elektrochem. Zeit.*, June. The author considers that very poor electric conductivity of a substance indicates it to be a compound and not an element. To show that silicon is a compound he treated an alkaline solution of potassium silicate with high-tension alternating current, and found that he had at the end of the experiment less SiO_2 than at the beginning; he concludes some silicon was decomposed.

Alloys of Copper and Bismuth.—A paper on this subject was presented on April 4 before the *Faraday Society* by A. H. Hiorns, giving results of further research on copper alloys carried out in a similar manner to that on the copper-arsenic series (our Vol. II., p. 170). Arnold has investigated the effect of bismuth, from 0.1 to 0.5 per cent, on copper, and found that the investing membranes surrounding the grains of copper appeared to be split down the center, presenting a definite plane of cleavage. Gautier obtained a freezing-point curve similar to the author's, but his temperatures are generally higher.

The microscopic evidence mainly confirms the records of the freezing-point curves, of which there are four branches. We have pure copper and pure bismuth at the extremes, and solid solutions of copper in bismuth or bismuth in copper at intermediate points. The types of pattern on the etched surfaces depends on the position of the freezing points on the curve. The eutectic points occur at 243° C. and 1020° C., with a transition point at 858° C. From this point, with increase of bismuth in alloys containing 30 to 43 per cent of copper, the curve is practically a horizontal line, showing little differences in the freezing points. In this region two possible chemical compounds may be present, viz., Cu_3Bi_2 and Cu_3Bi, but there are no well-marked indications of such, either in the freezing-point curve or in the microsections. Such compounds can, therefore, only exist in contact with solutions containing excess of bismuth. The above-mentioned transition point is the transition point between solutions of copper in bismuth and bismuth in copper, and at this point the two solutions have probably the same freezing points, each being lowered by the addition of the other, thus forming a conglomerate of the two mixed crystals, which here exist in equilibrium.

Copper, with small percentages of bismuth, consists of polygonal grains, the boundaries of which contain a thin line of bismuthide. When such copper is broken the line of fracture follows this line. With 2 per cent bismuth the surface shows a characteristic eutectic structure. With increase of bismuth gradually widening boundaries to the grains appear and the interior is of a eutectic nature, which also increases with the addition of bismuth. With 57 per cent bismuth the whole surface is composed of grains of the two solid solutions, one of a light-gray and the other of a light-red color. With 60 to 67 per cent bismuth the alloys are composed of the two solid solutions mentioned above, with the addition of dark-blue grains, probably the compound Cu_3Bi. With 70 to 90 per cent of bismuth there are two main constituents, consisting of the red solid solution in a eutectic mixture. With 97.2 per cent of bismuth the whole is decidedly a eutectic mixture. The structure of alloys containing 98 per cent bismuth and upwards resembles pure bismuth.

Radioactivity as an Atomic Property.—It is now generally considered that the radioactivity of any element is independent of its form of chemical combination; that, in fact, radioactivity is a property of the atom rather than of the molecule. There is already much evidence in favor of this view. Thus, it is well established that the rate of decay of activity of temporarily radioactive products is wholly independent of the chemical as well as physical conditions. Further, all compounds of radium and uranium are active, as are also, probably, all those of thorium. The radioactivity of pure uranium compounds is roughly proportional to the percentage of uranium. The latter point has been studied in detail by Herbert N. McCoy, who gives the results of his investigation in the April issue of the *Jour. Am. Chem. Soc'y.* His experiments show that the effective (or directly observed) activity of the layers of uranium compounds, sufficiently thick to show the maximum alpha-ray activity, depends not only on the uranium content but also on the coefficient of absorption of the rays by the radioactive substance itself. When this absorption is taken into account the total alpha-ray activity of any uranium compound is strictly proportional to its percentage of uranium. This is a direct confirmation of the theory that radioactivity is an atomic property.

Metallurgy of Lead.

Lead Smelting Works at Monteponi, Sardinia.—The Monteponi smelter is the largest zinc-lead producer in Italy, and treats the complex local zinc lead ores. A brief illustrated description of the method of treatment adopted at the works is given in the *Oester. Zeitsch. für Berg. u. Hüttener*, Sept. 2, by E. Ferraris, the manager. The smelter receives: 1. Lead carbonate ores with some zinc oxide, which are sieved through a 10-millimeter screen, the part which remains on the sieve going directly to the blast furnace charge, while the part which passes through the sieve is roasted with lead sulphide ores or sintered by itself; 2, lead ores consisting of quartz with 10 to 15 per cent lead, which are smelted directly in addition to the lead carbonates, and 3, lead sulphides, which are ground fine and roasted. During the roasting there is added quartz sand, for the purpose of driving out the sulphuric acid and obtaining an easily fusible lead silicate. The roasting is carried out in two hand roasting furnaces, which are 18 meters

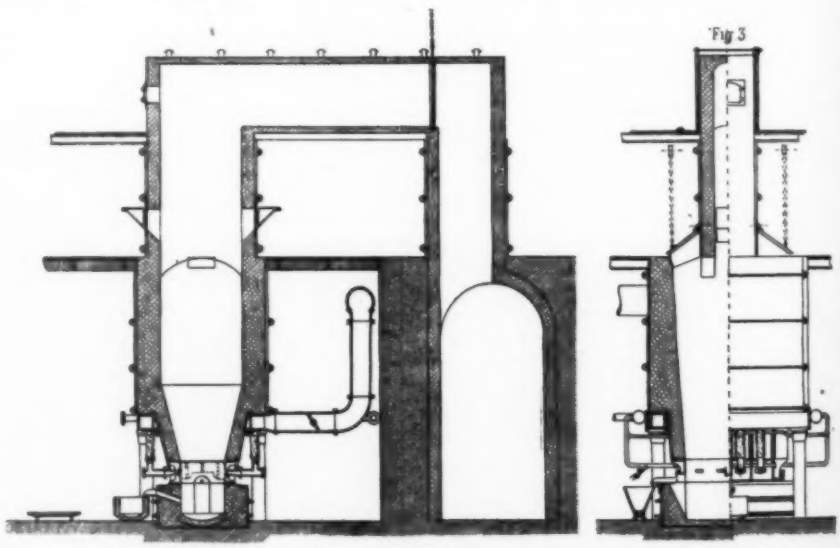

FIG. 2.—LEAD BLAST FURNACE AT MONTEPONI.

long, and have a capacity of 12 tons of roasted product in 24 hours, with a consumption of 1800 kg, or 15 per cent of English bituminous coal, or 20 per cent of Sardinian brown coal. The smelting furnace charge consists, as a rule, of 50 per cent ores, raw and roasted, 20 per cent fluxes and 30 per cent slag from the works. The fluxes are limestone, with 98 per cent CaO_3 and limonite. The latter ore contains 48 per cent Fe, not over 4 per cent Zn, some lead and traces of copper and silver. One blast furnace smelts in 24 hours 60 tons of charge, or 30 tons of ores, with a coke consumption of 12 per cent of the charge and a wind pressure of 30 per cent to 50 millimeters mercury. The furnace shown in Fig. 1 consists of a firebrick structure, which in place of ordinary water jackets is provided with cooling plates in the smelting zone. These plates are 0.50 meters high, and can be cooled as desired by means of sprays of water. This arrangement is stated to entail a lesser consumption of water for cooling purposes than would be the case with cooling jackets, inasmuch as a part of the water evaporates and the danger of leakage is prevented. The crucible is provided with a cast-iron tube, 0.10 millimeters wide, for the purpose of conducting the lead to the outer kettle; this tube is slightly inclined in a downward direction, in order to prevent the escape of slag. The lead is tapped every 20 minutes. The condensing arrangement for the flue dust consists of a chamber, 3.40 meters wide and 1.60 meters long, which is divided by one longitudinal and five cross walls into twelve compartments. The gases change their direction seven times, and pass thereby six times over the longitudinal wall, in doing which they are met by fine sprays of water. The latter use 1.5 liters per minute each, of which four-fifths evaporate and one-fifth flows into a collecting reservoir. By this means 10 to 15 per cent of the entire flue dust are precipitated in the condensing chamber itself, and are removed from time to time in the shape of a thick liquid through openings provided for this purpose.

METALLURGY OF IRON AND STEEL.

Bertrand-Thiel Process in the Manufacture of Steel.—In a paper presented before the Iron and Steel Institute in London, on May 11, by John H. Darby and George Hatton, attention is called to the many attempts which have been made to accelerate the open-hearth process of making acid or basic steel by increasing the size of furnaces, perfecting the machinery for charging the furnace, using molten iron from the blast furnace in conjunction with a mixer, etc. In all of these it has been found essential to use pig metal of special composition—not always easy to obtain, and often difficult to manufacture. The Bertrand-Thiel process is really a two-stage cleansing process. In the first furnace the bulk of the phosphorus, the whole of the silicon, and part of the manganese and carbon are removed; while in the second furnace scrap, ore and lime are added to the already fluid metal. The slag from the primary furnace of such a combination would often yield from 25 per cent to 28 per cent of phosphoric acid. As this process was worked by Bertrand, six to seven 20-ton charges of soft steel were secured from a pair of furnaces in twenty-four hours. At Brymbo, with a more highly phosphoric pig iron, this rate had been maintained. At the Hoesch works, in Dortmund, ten charges have been regularly produced per day. In the case of two works employing the Bertrand-Thiel process, the pig iron containing a high percentage of phosphorus, it was found advisable to employ a gas-heated mixer, in fact, a large tipping gas-heated furnace. In it the molten metal from the blast furnace is poured and retained for use as required, week-end metal melted, desulphurization takes place, and the percentage of silicon is reduced. If a temperature of about 1500° C. is maintained in the furnace, cold pig iron is readily melted, and the wear and tear of the furnace is slight.

Analyses of the metal finally yielded showed that the carbon largely remained, the silicon was almost all eliminated, the sulphur reduced, and 61.5 per cent of phosphorus removed. Counting the mixer as a primary furnace, three furnaces were engaged, the two secondary furnaces charged with 25 per cent scrap working up the output of the mixer with forty-two 20-ton charges between three furnaces, or fourteen charges per week per furnace. In conclusion, the authors state that by partial preliminary refining in one furnace, pig iron of almost any ordinary composition can be commercially treated.

Continuous Steel Process in Fixed Furnaces.—This is the subject of a paper read by S. Surzycki, on May 5, before the Iron and Steel Institute in London. At the Czenstochowa Works there is at work a 25-ton furnace of the following dimensions: The length between blocks, 26 feet 3 inches; width, 8 feet 7 inches, and depth of hearth from 1 foot 8 inches to 2 feet. During its first campaign it made 574 charges by the continuous process, whereupon, whilst still in quite good condition, it was stopped for certain local reasons. After repairing the ports and the roof and repacking the chambers, the furnace was again put into work, and since then has already made over 690 charges, and will, it is hoped, keep at work up to the 1000 charges.

The process is based on the idea and the principle of the Talbot process, with the essential difference that it can be carried out in any fixed furnace of not less than 25 tons capacity. This practice is mainly based on the arrangement of two or more tapping-holes placed over each other, but not arranged in a vertical line, such tapping-holes leading into a double launder by which the whole of the contents of the furnace, or only a part of the contents, may be easily emptied at any time. The tapping-holes are arranged in a cast-iron plate, lined up with magnesite bricks and stamped dolomite; they give no trouble, since they can neither slip nor sink, nor yet be corroded. The hearth of the furnace stands perfectly, and remains sound for months without any repairs. As a rule, only the slag line, and to a less extent the blocks, require repair.

The chief material required for the continuous process is molten pig iron, which, in the case under review, is taken from a 70-ton mixer. Unfortunately, the chemical composition of the pig iron varies very greatly, and varying percentages of iron ore have to be added to secure the conversion of the graphite into combined carbon and the oxidation of the silicon and manganese. The percentage of phosphorus is often rather high; with more than 1 per cent of phosphorus the slag must be drawn off as quickly as possible after the end of the refining period.

The furnace makes usually three charges in the twenty-four hours, each of 25 tons; when the blast furnace is working well, and a pig iron with low silicon and manganese is obtainable, four charges can be made. Unfortunately, the author is not able to give exact figures as to coal consumption, since the producer plant is common to the whole of the furnaces, and it will only be when the new continuous furnace, now building, which will have separate producers, is working that it will be possible to give the coal consumption exactly. Of course, it is considerably less than the ordinary process, as the furnace when continuously worked stores up an immense amount of heat, and much less fresh gas than in the ordinarily worked furnaces is required. It can, however, be stated that the coal consumption for the whole steel plant (which consists of five furnaces, four of which are ordinarily in operation) since the introduction of the continuous process, has fallen about 9 or 10 per cent (reckoned on the production of good ingots).

The final making ready of the charge at Czenstochowa takes place partly in the steel ladle. The test taken from the furnace before tapping, and before the addition of ferromanganese, must be capable of being hammered out without any fault, must possess the wished-for hardness, must be perfectly de-

phosphorized, must show a perfectly sound fracture, and must remain quiet in the small test ingot mould. This being so, the charge can then be tapped, and at the same moment a regulated amount of finely ground ferromanganese is thrown against the stream of steel as it falls into the ladle. A fairly active reaction is thereby produced, which, after one to one and a half minutes, quiets down completely, and when the metal has stood for a short time teeming can be commenced.

The author carried out a parallel series of experiments on ingots made by the continuous and ordinary processes. In both cases the differences in the composition were very nearly the same; in the continuous process the differences as regards the carbon and manganese are rather less, and as regards the phosphorus rather greater.

These experiments demonstrated that metal made (*a*) by the ordinary process and (*b*) by the continuous process are similar to each other, and made it clear that the former fears as to the metal deoxidized in the ladle being less homogeneous than that produced by the ordinary process were perfectly groundless.

The continuous process can naturally be still further developed, but in any case it has shown, during the last two years of practical work, its capabilities and advantages. These advantages do not consist solely in the continuity of the process itself, but in the longer life of the furnace, the higher production and yield, the lessened fuel consumption, and also in the simplicity of the whole plant and of the whole practice. There may be here and there some imperfections in connection with it, as is the case with everything new, but these will, it is to be hoped, be overcome with time.

Automatic Stock Line Recorder for Iron Blast Furnaces.—in a paper published in the May issue of the *Bi-monthly Bulletin* of the American Institute Mining Engineers, J. E. Johnson, Jr., describes in detail an automatic recorder of the status of the stock in a blast furnace. The device consists essentially of a test rod suspended at its top by a chain, but normally resting on the stock and descending with it, except when the bell is open; a simple mechanism is provided for lifting this rod out of the way on the incoming stock at the latter period. An attachment records its motion on a reduced scale.

Metallurgy of Gold.

Some Suggestions on the Cyanidation of the Tailings.—In the *Journal* of the Chemical, Metallurgical and Mining Society of South Africa, June, 1905, Prof. Prister outlines a method for cyaniding tailings which differs from that usually adopted. His discussion is based upon results which he obtained by leaching batches of 280 tons of sands with a preliminary wash of 0.057 per cent KCy, followed by a strong solution of 0.25 per cent KCy, which in turn was succeeded by a medium solution of 0.17 per cent KCy and a final wash of 0.05 per cent KCy. He ascertained that of the 388 tons of cyanide solution which were used for treatment, and which were made up of 20 tons of weak solution as a preliminary wash, 51 tons of strong solution remained in contact with the sands, 50 tons of strong solution for leaching, 153 tons of medium solution for leaching, and 134 tons of weak solution for leaching, about 208 tons contained more than 2 dwt. of gold in solution, while the remainder contained less. He therefore raises the question whether it is economical and necessary to pass all the solutions through the boxes, as is the usual practice, or whether it would not be better to pass only the first two-thirds of the solution through the boxes and run the last third directly to the sump. The first two-thirds of the solution leaching from the cyaniding vats are then rich in gold, and contain the highest percentage of KCy. Consequently, a good precipitation is assured, when the strong solution goes to its corresponding precipitation box and then to the strong solution sump, while the medium solution passes through its corresponding box and sump. The strong and medium solutions will, therefore, have passed through their boxes, and have lost all their gold and a part of their KCy, while the weak solution still contains all of its gold and KCy, as it has passed directly to the sump. For the next charge, therefore, the strong solution is made up with KCy to the required strength and used as above. For the medium wash, however, not the medium solution from the medium sump is taken, but in its place there is used the solution contained in the weak solution sump, which latter still contains its gold and all of its cyanide, as outlined above. This solution will dissolve more gold, and will then come from the leaching tanks partly as medium and partly as strong solution. For the weak wash of this second charge there is used the solution from the medium solution sump, which is pumped on the tank and drawn off into the weak solution pump, to be used as medium solution for the third charge. The subsequent charges will be treated in the same manner. The author describes a calorimetric method by which the control of the solution, as far as their classification into strong, medium and weak solution is concerned, may be effected with sufficient practical accuracy. It consists in adding a few grains of zinc dust or zinc fumes to 100 cc. of the solution, and strengthening it further with KCy by the addition of a few drops of strong KCy solution. The solution is then warmed gently for about 5 minutes and filtered, the excess of zinc dissolved with dilute sulphuric acid and filtered again, and the residue dissolved in about 10 cc. of aqua regia, made up of 3 parts conc. HCl, 2 parts conc. HNO_3, and 2 parts H_2O. A few drops of a solution of stannous chloride are then added, and the color obtained will indicate the richness of the solution. The advantages of the method thus proposed consist in the using up of a lesser quantity of zinc as well as of KCy in the boxes, the possibility of getting along with a lesser number of precipitation boxes, and therefore a smaller plant and the production of zinc slimes richer in gold, inasmuch as the solutions which are passed through the boxes are richer in gold. As the largest quantity of white precipitate is also formed in the weak boxes, and as in the outlined method weak solutions are not passed through the boxes, the latter will remain in a better working condition.

Cyaniding of Concentrates by Percolation.—A brief account of the method in which some 210 tons of accumulated concentrates, assaying 60 dwt. of gold to the ton, were treated by percolation at the Clutha gold mines at Barberton, Transvaal, is given by A. L. Edwards in the June, 1905, issue of the *Journal* of the Chemical, Metallurgical and Mining Society of South Africa. The concentrates were ground in a small ball mill and passed through a 1600-mesh standard screen, sampled, taken to the treatment vats, where they were first washed with water and 4 pounds of lime per ton of concentrates added. A first weak solution of 0.05 per cent KCy was then run on, and leached off, which was followed by a medium solution of 0.1 per cent of KCy. This was leached off and the concentrates were turned over. A strong solution of KCy (0.75 per cent) was then run on and allowed to remain in contact for 12 hours, after which the solution was drawn off and all the dissolved gold washed out as rapidly as possible. This treatment was repeated on three subsequent occasions, with the result that the extraction was brought up to 93 per cent. The time occupied in treatment was forty days, which could have been reduced by 25 per cent if time had been allowed for grinding the concentrates finer. The consumption of cyanide was rather high, owing to the concentrates not having been roasted. The leaching was good and the purification was excellent, the action being so strong as to necessitate the flow being reduced to 2 tons per hour. Two-thirds of the gold, amounting to 390 ounces, was precipitated in the first three weeks. In the strong box only clean zinc was used, whilst a zinc-lead couple was used with good effect in the weak box, the solution leaving the box with from 6 to 8 grains of gold. The strongest solution used was 0.75 per cent, and the weakest 0.08 per cent, with a final water wash. Towards the end of the treatment

period the white precipitate made its appearance in the weak box.

Methods of Charging a Tavener Pan Furnace.—In a paper before the Chemical, Metallurgical and Mining Society of South Africa, Mr. H. Rusden gave a brief outline of the way in which the Ferreira pan furnace for smelting clean-up material from the cyanide works is charged. The fire is lighted about ten hours before the cyanide clean-up is ready, by which time the whole brick work is thoroughly hot. Any by-product lead that happens to be on hand is then melted in the furnace in order to form a bath. A little litharge may be reduced to serve the same purpose. The furnace damper is then closed tightly and a few shovelfulls of roughly broken slag is thrown on the lead bath. The wet clean-up mixed with the necessary amount of fluxes is then charged upon the bath. This clean-up in its turn is covered with crushed pan-slag from previous meltings, which pan slag is broken to about ⅜-inch tubes. The furnace damper is not opened until about twenty minutes later, and during this time the radiated heat from the furnace renders the slag cover pasty. This method of procedure prevents, to a great extent, any dusting. The fire is then urged on and the smelting is continued as rapidly as possible. When the first charge is smelted down level the second charge is put in under the same precaution as the first.

Tube Mills for Fine Grinding of Gold Ores.—Attention has been called frequently in the pages of Electrochemical and Metallurgical Industry to the importance which the tube mill, as an instrument for fine grinding of gold ores as an auxiliary to stamps, has already acquired up to this time, and that it is likely to play a still more important rôle in the future. Various attempts have been made to gain some idea as to the theoretical manner in which it performed its duty, yet the subject is so much in its infancy that there is still a large field open to research. Some further contribution to the theory of the tube mill has lately been made by H. A. White, in a paper read before the Chemical, Metallurgical and Mining Society of South Africa, and published in the May issue of the *Journal* of that society. In a general way the author concurs with the views of Herman Fischer, published in the *Zeit. Bes Vereines Deutscher Ingenieure*, namely, that the pulverising action is due almost entirely to the actual impact of the falling balls when the mill is crushed dry. However, when the mill is half full of water Mr. White thinks that that conclusion will require some modification. As a ball falling into 2 or 3 feet of water will not strike the bottom with enough force to do much crushing, he thinks that in this case it is probable that the grinding action between the balls will do a great proportion of the work. Thus the speed of the revolution would require to be so adjusted as to avoid an unnecessary amount of practically wasted fall, and would be best regulated so that the angle of repose of the crushing material is alone considered. Mr. White goes into a very extended mathematical calculation of the action of the balls in the tube mill, calculating a number of quite intricate formulæ. He also gives a table of diameters of the tube mills in inches and meters and the theoretical speed of revolution calculated in order to obtain the best results. As one of the salient features of the results of his experiments he mentions that as far as the running of the tube mill was concerned, a fairly efficient fall would be obtained if the tube were filled to the extent of two-thirds (when at rest) with balls. While relying on the fall for the crushing part it is, however, obvious that in all cases it cannot pay to waste energy in splashing water—the autlet must, therefore, be arranged so that the depth of the water does not much exceed the depth of the balls on the bottom of the tube mill, as shown in any diagram showing the mill in motion. In concluding his remarks about the subject Mr. White is of the opinion, however, that the question of the best diameter and length of the tube mill and the material and size of balls seems to be so essentially one to be determined by experiments on a working scale that he does not venture to offer any remarks upon it. In his opinion a practical method of determining the best speed at which any tube mill should be run when fitted up for working would be by indicator diagram or measurements of current, so as to determine when the power absorbed, divided by the number of revolutions per minute, became a maximum.

Milling in India.—The Champion Reef Mine is one of the most important of the gold mines in India on the Kolar gold field, and has yielded already an enormous amount of gold. A description of a method of treatment of the rock by R. F. J. Weeks is given in *Mines and Minerals*, Aug., 1905. The ore is a free milling one, and is treated in three mills of 120, 50 and 60 heads respectively. In the first of these mills the stamps are arranged sixty in a row, face to face, the ore bins behind each row. The stamps have a falling weight of 1250 pounds, comprising the stem, 16 feet x 3½ inches, 518 pounds; the head, 2 feet x 9 inches, 368 pounds; the shoe, 12 inches x 9 inches, 237 pounds, and the tappet, 12 inches x 9 inches, 127 pounds. The stamps drop 8 inches at about ninety-four blows per minute. The mortar boxes are of the heavy Homestake pattern, 4 feet 8 inches high by 4 feet 9 inches long by 13 inches wide, inside measurements without liners. The order of drop of the stamps is 1, 3, 5, 4. The amalgamating tables are silver-plated copper, with an inclination of 1⅛ inches in 1 foot. They are of the step pattern, that is, instead of one continuous length of plate there are two sections, each 5 feet long with a drop of 2 inches between the top and bottom sections. The tables are not of uniform width, as the top section is 5 feet square, but the bottom section is tapered at the discharge end to 3 feet. No traps ar eused, but rifles are provided at the bottom of the tables for catching coarse amalgam. There is one table to each battery of five stamps. No inside plate is used, but chuck blocks, 6 inches in average width, are employed. Woven wire screening of 30-mesh is used. The mill is driven by electric power derived from a main station at a place some 92 miles from the field, known as the Canvery Falls, the Canvery being one of the principal rivers of Southern India. The mill is supplied with a three-phase alternating current of 25 periods per second, the supply voltage being 2200. The tailings flow through vats, where the separation of slimes and sand is effected preparatory to their being treated by the cyanide process. The average assay value of the ore crushed was 1 ounce 2 dwt., seven grains of fine gold per ton yielding an extraction of 18 dwts., one grain of fine gold per ton.

Bisulphate of Sodium in the Cyanide Clean-Up.—Owing to the fact of its having been observed that the rate of solution of zinc in bisulphate solution was greater than that in sulphuric acid of equivalent strength, J. E. Thomas and G. P. Williams carried out a series of laboratory experiments with a view of determining the following points: 1. Comparative rate of solution of zinc in equivalent solutions of sulphuric acid and acid sodium sulphate (bisulphate). 2. Maximum working strength of the bisulphate. 3. Maximum strength of the stock solution. 4. Effect of temperature, electrolytic couples, etc. The results of these experiments are described by them in a paper read before the Chemical, Metallurgical and Mining Society of South Africa, and published in the *Journal* of that society June, 1905. The paper also contains a detailed description of a series of trials on a large scale, which proved quite satisfactory. For a trial at the cyanide works of the Simmer and Jack mine, the solution of bisulphate was prepared as follows two days before the clean-up: A stirring gear was fitted in one of the lower acid vats, 10 feet in diameter and 4 feet 7 inches deep, and a wooden platform of 2-inch slats 2 inches apart was suspended from the top. The sodium bisulphate, previously broken to about 4-inch cubes, was placed on this platform, the vat was then filled with hot water until the platform was submerged and the stirring gear was started. Altogether 7556 pounds in all were dissolved, the total volume of

water being 9 tons, so as to make a solution of approximately 11 gms. H_2SO_4 per 100 c. c. The whole amount of bisulphate dissolved in about five hours. The solution stood for about forty hours before use, and showed no sign of crystallization. In order to make as severe a test as possible the gold-carrying zinc from one of the weak cyanide boxes was taken without any cleaning whatsoever. On the morning of the clean-up, part of the solution was elevated to the zinc dissolving vats by means of a monteju, and the zinc from the weak box was fed into the solution. At first the action was not considered satisfactory, and hot water was added, and the strength of the solution brought down to about 9 gms. H_2SO_4 per 100 c. c.

This increased the action considerably, and the zinc dissolved briskly until the acid was used up, when all action ceased. The contents of the tubs were then transferred to the settling vats for washing, and the settlement obtained was good. More acid was then elevated to the tubs, diluted with hot water to about the same strength as before, and more zinc added until the action ceased. The liquid was then lowered again, and the process repeated until the acid solution had all been used up. The total moist weight of zinc from the weak box dissolved was 2201 pounds, *i. e.*, 1 pound of free acid in the bisulphate dissolved approximately 1 pound of moist zinc (unwashed). A noticeable feature during the solution of the zinc was the entire absence of that extremely unpleasant odor usually associated with a zinc plant clean-up, which the author contributed to the freedom of the gases from arsine, usually formed when zinc is dissolved in sulphuric acid which contains more or less arsenic in solution. The sulphuric acid used in the preparation of bisulphate is manufactured from pure silicon sulphur and free from arsenic. This point is considered by the authors of the paper to be of great importance in view of the extremely dangerous effects of arsine poisoning, as a man once overcome by gas at the zinc dissolving vats is always very liable to be overcome by fumes later on, and the effect is then much more severe. Another feature of importance was that although a most unusual quantity of zinc was fed into the tubs there was not the slightest tendency to boil over. The washing and filter pressing of the gold precipitates was carried out in the usual manner and the cakes calcined, placed, fluxed and smelted in clay liners in a reverberatory furnace. The solution when being run to the settling vats analyzed as follows: Free acid, nil; zinc sulphate, 13.32 per cent; sodium sulphate, 20.82 per cent; free acid originally present, 8,23 per cent. The acid plant at the Simmer and Jack works is now being reconstructed to allow of the use of sodium bisulphate throughout the clean-up, and it is expected that a saving of well over 55 per cent will be effected in the cost of the acid. With a properly designed plant the labor required would be no more than when using commercial sulphuric acid, as the soultion of the bisulphate could be performed by the usual labor on the works, and the coal required would be little more than is used at present.

Mercury.

Mercury-Ore Roasting Furnaces.—The large roasting furnaces for mecury ore at the mercury works of Idira, Austria, were provided with an open throat, which is covered to a depth of about 80 cm. with a layer of ore 3 to 20-millimeter size. This layer was not sufficient to entirely prevent the egress of the roasting furnace gases, which contained mercury, and therefore poisoned the workmen to a considerable extent. In order to prevent this occurrence, L. Buchal, the superintendent of the works, introduced an arrangement which he briefly describes in the *Oest. Zeit. f. Behg., p. Hüettenwesen*, July 15. In principle, it consists in drawing away the gases which enter the layer or ore mentioned above, for which purpose canals are formed in this layer by means of cast-iron roof-shaped pieces. There are six of these canals in each shaft of the Czermak-Spirek roasting furnace, and twenty-four in the whole furnace, inasmuch as the latter has four shafts. The canals collect the gases and conduct them to longitudinal canals, in which there is maintained a comparatively high depression. A suction action is therefore also exerted in the gas-collecting canals in the cover of ore, and thus the gases are drawn away. This device, the author states, has proven entirely satisfactory. This action does not disturb the roasting furnace gases, which pass from the furnace through a pipe condenser, the chambers and flues. The canals for drawing away the gases in the ore cover do not lead to a pipe condenser, but the gases are carried directly into the main flue.

BOOK REVIEWS.

Transactions of the American Electrochemical Society. Vol. VII. Philadelphia: American Electrochemical Society.

This volume covers the proceedings at the seventh general meeting, held in Boston, Mass., from April 25 to 27. All the papers contained in the volume were abstracted in the report of the meeting in our May issue.

It seems that the statement in our report of a remark, made by Dr. Theo. W. Richards, in the duscussion of Dr. H. W. Patten's paper, has given rise to some misunderstanding. Our report stated that "Dr. Theo. W. Richards objected to Patten's statement that he has applied Helmholtz' formula while he used apparently Thomson's rule, thus using the total energy instead of the free energy. A complete treatment of the case would involve far more experimental work."

According to the Transactions, Dr. T. W. Richards said: "In this paper Dr. Patten speaks of having used Helmholtz' formula in calculating his results. I ask information. It seems to me he has rather used the equation of Berthelot or Thomson. That is to say, has confounded total energy and free energy. Now, if it is true that in this particular case the total energy is equal to the free energy charge, that is, that the cell has no temperature coefficient, it is an interesting case, and one which is well worth while studying further on this account. On the other hand, in view of the fact that Dr. Patten acknowledges decomposition at the electrodes, the conditions are uncertain, and the investigation, as presented to us, is an interesting beginning rather than a complete treatment of the subject. Being given as a complete treatment, a portion of it appears to be distinctly misleading."

In a reply, communicated for publication in the Transactions after the meeting, Dr. Patten states that it seems to him that our review gives a false impression both of Prof. Richards' attitude toward his paper and of the paper itself; that he has not yet determined the temperature coefficient; that in his paper he referred to the use of Helmholtz' formula, because he had been thinking in terms of that formula and omitted the temperature coefficient only until it should be determined experimentally; that he used the words "rough" and "tentative" in the two critical places, and that he did not consider the problem as finished. By the application of Helmholtz' formula Dr. Patten calculates the probable magnitude and sign of the temperature coefficient, and finds it would be + 0.000443 volt per 1° C., "a value rather high but not impossible." (But it remains to be proven experimentally that the total reaction in the cell is reversible—otherwise Helmholtz' formula cannot be applied.)

The frontispiece of the volume is a portrait of the president of the society, Dr. Wilder D. Bancroft, but scarcely does his normal smiling countenance full justice. The editing of the papers and discussions appears to have been carefully done.

Hot-Blast Smelting.

Hot-blast smelting is now engaging the serious attention of many intelligent metallurgists. In iron smelting the hot blast has made high blast pressure possible, without which furnaces of large cross-section could not be blown. There is no

condition of blast temperature applying in iron smelting that does not apply with equal force and effect in lead smelting, for gold and silver, in copper matting and pyritic smelting—although, of course, each case has its own peculiarities.

In its recently issued very interesting book on "Some Details as to Smelting Practice and Equipment," the Colorado Iron Works Co. devote considerable space to the thorough discussion of the problems of hot-blast smelting. We believe the following abstracts from this book will be of interest to our readers:

In blast furnace smelting of gold, silver, lead and copper ores, conditions at the incandescent zone above the tuyeres for oxidation and reduction are controlled by volume, temperature and pressure of blast with reference to cross-section of the furnace at the tuyeres, character of the material being operated upon and end results accomplished. In the use of hot air provision must be in tuyere area to accommodate and allow the passage of its vastly expanded volume.

Heating air blast by reason of its vastly increased volume tends to facility of distribution and not to localization of combustion. Thereby uniform action is rendered possible by elimination of much of the cold otherwise carried in by the air blast and circulated or distributed irregularly and without control. In the exact proportion that a given quantity of air is increased in volume by heat, the practicability of its thorough distribution and contact with every atom of exposed material, and hence of uniformity in degree of combustion at the zone of fusion and in the desired conditions throughout the other auxiliary zones respectively, is realized.

There are large proportional areas, especially in the neighborhood of the tuyeres, in every cold-blast furnace, in which the desired reaction cannot take place because the blast of cold air keeps these areas too cool to admit of them. Proportionately as the air is sent hot into the furnace these cool areas are reduced in size and in far greater proportions are the capacity and efficiency of the furnace increased. Eliminating the element of cold from the air blast removes the one unmanageable factor in blast furnace smelting; it is unmanageable because the course or direction of the air when it enters the furnace is largely determined by the dark areas and patches of cold material, rendered so dark and cold by the cold of the air blast and against which it impinges.

In cold-blast furnaces there is a constant tendency to burn too high up above the tuyere zone, which is caused by the cold air cooling relatively all material at the tuyeres, while the air is being heated up to the temperature at which it is possible for it to become a factor in the reactions to which it is necessary.

Hot blast contributes to support the combustion of carbonaceous and other fuel, as sulphur, etc., with a minimum of oxygen applied, *i. e.*, the hot blast and fuel are drawn upon most for the necessary smelting reactions, and least possible for heating *per se*.

Of greatest importance is the proportionate quantity of hot air as compared with cold air involved in smelting. Let us assume a furnace, 42-inch x 168-inch cross-section at the tuyeres, into which 10,000 cubic feet of cold air is blown per minute, and 300 tons per 24-hour day of sulphide and other ores, fluxes and fuel are charged in, the percentage of good coke being 11 per cent of the charge.

The 10,000 cubic feet of air blown in each minute weigh 761 pounds at sea level, with normal temperature 62° F.; 300 tons charge per day is 417 pounds per minute; the coke, being 11 per cent of this, is 46 pounds per minute. To burn pure carbon two and two-thirds its weight in oxygen is required. Assume 10 per cent off, which must be accounted for as silica in the charge of coke, for ash and other waste, and there is left 41.4 pounds of carbon, which, multiplied by two and two-thirds, gives 110.4 pounds of oxygen, or 480 pounds of air, the extreme minimum possible. This, from 761 pounds of air blown in, leaves 281 pounds of air per minute absorbed in burning sulphur and iron in other reactions, and some passing through the furnace unchanged. An ore charge that has enough sulphur in it to run cold-blast on 11 per cent fuel charge, will always run on 3 per cent and less with 800° F. hot-blast.

By calculation as before, but now applied to hot-blast, 3 per cent of the charge being fuel would absorb 131 pounds of of air, which added to 281 pounds blown in the cold blast and not accounted for as combined with carbon, assumed again as excess in the case of hot-blast, makes a total of air required to drive the hot-blast furnace 412 pounds, or 5400 cubic feet of air, required in hot-blast furnace for a given duty, as against 10,000 cubic feet in the cold-blast furnace. Hence only 5400 cubic feet of air must be pre-heated in the stove for this purpose, and that with a cheaper fuel, as against 10,000 cubic feet to be heated at the tuyere zone of the cold-blast furnace with expensive coke. The stove thus proves an economy in heating the necessary air alone, and the fact is brought out that, by heating the air, the smelting capacity of any given size of furnace is very greatly increased—nearly doubled, in fact—under average conditions and proportions of material in the ore charge. The furnace that used 10,000 cubic feet of cold air per minute, blown in at the tuyeres, has capacity for a like 10,000 cubic feet of cold air heated up to, say, 900° in a stove, while, as shown above, the heated air in the latter case is equal to serve in smelting capacity to nearly double that of the like amount of cold air blown directly into the furnace.

The cold or deficiency temperature carried into the tuyere zone of a cold-blast furnace by the air necessary to smelt a ton of ore, is more than one and a half times the cold or deficiency temperature incident to the ton of ore charged in, and it takes more than one and a half the number of heat units to heat this air to the smelting temperature than it does to to heat the ton of ore to the melting temperature. So great a proportion of cold introduced at the tuyeres is certainly an active disturbing factor, and must be prolific of furnace irregularities.

In hot-blast smelting of sulphide ores, but one-half, or sometimes three-fifths, as much air is necessary as in cold-blast smelting of the same ores, and, therefore, but a proportional cost is involved in heating the air used; that is, but one-half or three-fifths as much in value of fuel is expended in bringing the air necessary to drive a hot-blast furnace up to the ultimate smelting temperature as is required for a cold-blast furnace.

The difference in the amount of air required is owing to the smaller quantity of carbonaceous fuel necessary to be burned in the hot-blast furnace. Every pound of carbon saved saves also 140 cubic feet of air, for it takes 140 cubic feet of air to burn a pound of carbon. It is true that oxygen is necessary to the burning of sulphur for the production of heat, but it is also true that a cold-blast furnace has to burn the sulphur, and uses as much air in burning that sulphur as it is burned there, as a hot-blast uses in bringing the sulphur to complete combustion, and utilizes it as an available fuel in the smelting operation. The sulphur in the charge has to be gotten rid of—burned up—except that retained as a constituent of the matter. It will not burn when exposed to a blast of cold air; therefore, in a cold-blast furnace a lot of coke has to be charged in and the air heated thus to burn the sulphur, for the sulphur must be burned to dispose of it, so excess of air over that needed for burning the coke, must be blown in and heated by the coke to burn the sulphur. Thus it is evident that it takes as much heated air to destroy and so get rid of the sulphur in a cold-blast furnace as it does to utilize it as an available fuel when smelting with hot-air blast.

In the cold-blast furnace the cold air is blown in at the tuyere zone, and a part of it is there absorbed in keeping up the coke fire, while the excess over that so used is heated at that point, and passes thus hot into the zones of the furnace above, and there contributes the necessary oxygen to burn the

sulphur. For this reason most of the sulphur is burned high up in the cold-blast furnace instead of being burned at the smelting zone, where its calorific effect can be of any value in the smelting operation. Sulphur will not burn in a blast of cold air without the addition of carbon. Sulphur does burn without the addition of carbon in a heated air blast.

When sulphur is burned in the higher zones of the furnace its tendency is to carry the smelting zone bodily high up, and when this occurs the furnace soon freezes up. Burning much sulphur above, as must always be done in a cold-blast furnace, contributes to, and usually produces, hot top; and hence cold-blast furnaces running on a high sulphur charge nearly, or

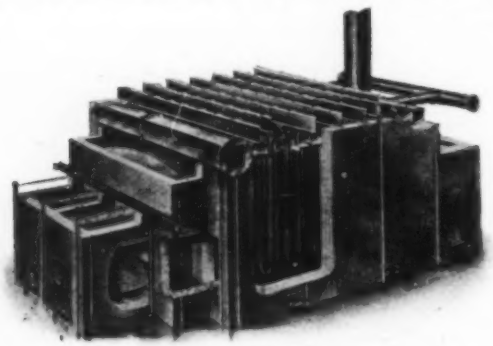

FIG. 1.—HOT-BLAST U-PIPE STOVE.

quite, always run with hot top, and the heat wasted in a hot top is usually enough to run the whole furnace if applied in the right place—the tuyere zone. With the air blast heated to 800° or 900° F. all sulphur is burned at and near the tuyeres, and thus the smelting is done by the aid, chiefly, of burning sulphur instead of coke, as is the case in the cold-blast furnace.

In iron smelting the air blast is heated by the waste gases, containing carbon monoxide. Little or no such gases escape from furnaces smelting the ores of copper, lead, silver and gold. In the latter case the Siemens regenerative or brick checker-work stove cannot, therefore, be used as it is in iron smelting. In its place, the U-type stove is very largely used. Fig. 1 shows the exterior and Fig. 2 a longitudinal vertical section of a hot-blast U-pipe stove, as made by the Colorado Iron Works Co.

The U-pipes are made of cast iron, and are so constructed

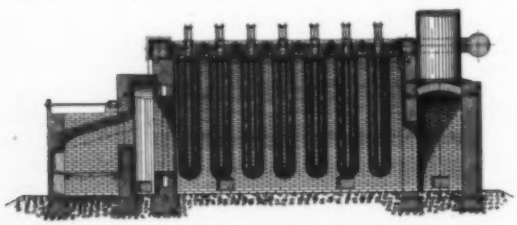

FIG. 2.—LONGITUDINAL VERTICAL SECTION OF HOT-BLAST U-PIPE STOVE.

that they will stand month after month at a low red heat without distortion or other damage. In order to provide ample heating surfaces the pipes are cast with longitudinal ribs on the inside.

The heating surface necessary for heating an air blast to 600° F. may be taken of as 0.4, and to 800° F. as 0.5 square foot for each cubic foot of air to be heated per minute. The extreme ultimate velocity of heated air on leaving the stove and in the pipes to the furnace should not exceed 5000 feet per minute. Air expands 0.002036 of its volume for each Fahrenheit degree added; therefore, when heated to 600° F. from 60° normal atmosphere, its volume has become 2.1 times its original volume, and hence all pipes and tuyeres must have more than double the area required for cold air of given amount in weight.

The Colorado Iron Works also have devised an oil stove hot-blast system for copper matting and pyritic furnaces. It comprises essentially a suitable chamber through which the air passes on its way from the blower to the furnace, and within this chamber in the atmosphere of the air blast an open fire of gas or oil is kept burning, the heat from which is absorbed by the passing air blast and carried thence into the furnace.

All the different advantages which are claimed for hot-blast smelting are summarized in the statement that when the air blast is heated, all matte smelting may be more satisfactorily done with less cost for fuel, with a cleaner slag, with higher tenor of matte, with less furnace irregularities, with increased furnace capacity and with less flue dust.

Metallurgy at the Lewis and Clark Exposition.

During the last session of Congress an appropriation was made to enable the United States Geological Survey to investigate the black sands of placer mines. Under the supervision of Dr. David T. Day, chief of the division of Mining and Mineral Resources, samples of black sands have been collected from placer mines of the United States, British Columbia, Central America and Mexico, and concentration experiments have been carried on all summer at the Lewis and Clark Centennial Exposition at Portland, Ore., in connection with the exhibits of mining machinery. A preliminary report on the progress of the investigation has recently been submitted by Dr. Day to the director of the Survey.

By the courtesy of the Lewis and Clark Exposition Co. a pavilion adjoining the Mines Building has been provided, 100 feet long by 50 feet wide, for the installation of concentrating machinery to carry on full-scale experiments as to the best methods of separating the useful minerals in various specimens of sand collected.

Prof. Robert H. Richards, of the Massachusetts Institute of Technology, is in charge of the concentration experiments. Invitations were sent out several months ago to all manufacturers of concentrating machinery in the United States, to send full-sized concentrating machines to this exposition for testing sands. As a result of this correspondence the following machines have been installed:

The Mine & Smelter Supply Co., of Denver, Col., has erected at its own expense a full-sized Wilfley concentrator, and has detailed Mr. A. W. Park to carry out any and all experiments in the concentration of sands that the Government shall direct.

The Joshua Hendy Machine Works, of San Francisco, Cal., have similarly installed the Pinder concentrator, which is under the personal direction of Capt. J. W. Pinder, the inventor. This company also operates a Hendy challenge ore feeder, which is in the charge of Messrs. J. Lee Anderson and Spencer Thompson.

The Woodbury concentrating table has been installed and is operated by the inventor, Mr. George E. Woodbury, of San Francisco, Cal.

Mr. C. Christonsen, of Oretown, Ore., has installed a Christonsen concentrator, and is operating it himself with Mr. Chas. D. Walcott, Jr., as assistant.

A new style of ore muller has been installed, and is operated by the inventor, Mr. I. J. Merrill.

A Wetherill magnetic separator, type E, of full size, has been loaned by the Wetherill Magnetic Separator Co., of New York. This machine is arranged to make separation of minerals at greater or less magnetic strength, ranging from a magnetic strength furnished by a current of 0.02 amp. to that furnished by a current of 3.5 amps. This is under the direction of Mr. Harmon V. Morse, of Johns Hopkins University.

Placed next to the magnetic separator is a set of the well-known Imperial ore screens, loaned by Mr. John Traylor, of Denver, Col., and manipulated under the supervision of Mr A. W. Park, assisted by Mr. Clifford L. Gardiner.

Two hydraulic classifiers, devised by Prof. R. H. Richards, are in process of erection. Prof. Richards has also installed an amalgamating table and a glass table with greased surface, such as is used in the South African diamond mines for separating special minerals.

Arrangements have been completed with the American Concentration Co., of Joplin, Mo., to procure a Knowles magnetic separator for quickly separating magnetic iron from black sands.

A rock crusher and an ore pulverizer are also installed.

With this equipment it is possible to treat as much as one carload of sand in 8 hours, although this amount has not yet been run in a single day.

Obviously the course of treatment to be used must vary greatly with the kind of sand to be treated. The sands are grouped in two classes: (1) sea sands, low-grade gravels and tailings from a number of dredges and their middlings from placer workings, and (2) heavy tailings from concentration, containing the residue from the cleanup from placer mines, etc.

The method of treatment so far developed for beach sands and tailings from placer mines has been to deliver the sand, after appropriate sampling, to the automatic feeder. It is then elevated to the roof of the building, passing over the Traylor screen, and is delivered to an automatic distributor, from which it is evenly fed by a current of water through four iron pipes to the several concentrating machines. These machines separate the sands into three portions—concentrates, middlings and tailings. The entire concentrates and middlings are collected, and samples of the tailings are taken out every 5 minutes. Samples of these concentrates, middlings and tailings are dried and then treated by the process devised by Mr. Henry E. Wood, of Denver, Col., by which the sands are first separated by the magnetic separator into six portions by five successively increasing magnetic fluxes, representing the chief minerals contained in the sands. These are finally separated by a hand batea. The end products thus separated and obtained are magnetite, chromite, garnet, olivine, monazite, zircon, quartz, gold and platinum. The amounts of these minerals are then weighed and the portions representing precious minerals are assayed.

An assay laboratory has also been installed and is now complete. This laboratory occupies a space of 20 x 20 feet in the Mines Building proper, courteously given for this purpose by the Lewis and Clark Exposition Co. It is under the immediate charge of Mr. Frederick W. Horton, of the Massachusetts Institute of Technology, chief assistant to Prof. Robert H. Richards, who directs the details of operating the concentrating plant. Assisting Mr. Horton are Mr. G. H. Shadinger, of Johns Hopkins University; Mr. Amos Loveland, Mr. Northrop Dawson, Mr. F. H. Hazard and Mr. L. G. Gillett, of Colorado Springs, Col.

Here the following apparatus has been installed, partly loaned and partly purchased of the F. W. Braun Co., of San Francisco, Cal., and Messrs. Eimer & Amend, of New York City: No. 40 Braun's combination crucible and cupelling furnace, with complete blowpipe apparatus and Cary hydrocarbon burner; the necessary crucibles, cupels, scorifiers, fluxes, etc.; and weighing devices supplied by Eimer & Amend, of New York City, including very fine pulp and button balances. This firm has also supplied a small electric furnace and electric hotplate. All the necessary chemicals and apparatus for making simple mineralogical determinations are found here.

In addition to being assayed, many specimens of concentrates from the various kinds of sands in process of treatment are run through a small glass classifier. This classifier, devised and made by Prof. Robert H. Richards, has twenty-four spigots and is capable of grading any material fed into it into as many different products, according to the settling power of each individual grain. The settling columns are of glass, allowing the operator to see just what is taking place in each column and enabling him to regulate the machine with great precision. Samples of sand which, on account of their small size, cannot be concentrated to advantage on the concentrating tables are put through this classifier and finished by the batea, and their values are thus successfully saved.

News and Notes.

Philadelphia Section American Electrochemical Society.—The first meeting of the new season is to be held on the evening of Oct. 6, at Soulas' Cafe, Fifth and Ludlow Streets.

Carbon Tetrachloride.—According to a recent consular report from Marseille, France, two manufacturers of that city have recently adopted tetrachloride of carbon for the extraction of oil, "with results satisfactory to themselves."

Hoisting Engines and Accessories.—Catalogue No. 126 of the Allis-Chalmers Co. on hoisting engines and accessories is an excellent, concisely written and profusely illustrated treatise on complete hoisting equipments made by this company. Everybody interested in hoisting problems will find this pamphlet a rich source of valuable information.

Gramme Monument.—A monument to the memory of Zenobe Gramme is to be dedicated on Oct. 7 in Liège.

Chemical Engineering Course at the University of Wisconsin.—Beginning with the fall of 1905, the College of Engineering of the University of Wisconsin offers a course in chemical engineering. It is the purpose of this course thoroughly to train students in the fundamental principles of both chemistry and engineering. For this purpose a five-year course is offered. The fifth year is not made obligatory, although, in some respects, it is the most important one, since in this year specialization and research work are provided for. Further details will be found in Bulletin 121 of the University of Wisconsin, Madison, Wis.

Electrolytic Lead Refining.—Messrs. Locke, Blackett & Co., of Newcastle-on-Tyne, England, are installing an electrolytic lead refinery under the patents of Mr. Anson G. Betts. The treatment of the lead bullion will be carried out about as described in our issue of Aug., 1903 (Vol. I., p. 407), while the slime will be treated by the new process of Mr. Betts, described in our issue of April, 1905 (Vol. III., p. 141). Dr. William Valentine is building the plant.

Artificial Graphite.—The International Acheson Graphite Co., of Niagara Falls, has doubled the capacity of its production by the large extension recently completed, and will use in future 2000 hp. instead of 1000 hp. as heretofore. According to the United States Geological Survey the value of Acheson graphite, made in the electric furnace, was $217,790 in 1904, while the value of all the graphite mined in the United States was $341,372.

The works of the Roberts Chemical Co., in Niagara Falls, were recently almost completely destroyed by fire. The company now considers rebuilding the plant. The products of the company are pure caustic potash and hydrochloric acid, the latter being obtained by combination of the hydrogen and chlorine gases evolved at the cathode and anode respectively in the electrolysis of potassium chloride.

Tungsten.—The Beaver Metallurgical Co. has just completed the installation of a large metallurgical and chemical plant at Beaver Falls, Pa., amply provided with the necessary furnaces and machinery for the manufacture of a long line of chemical and metallurgical products on a large scale, especially those of the rare metals. For the present the company will devote itself only to the production of metallic tungsten,

ferro-tungsten and all other tungsten alloys and compounds in any quantity and in any degree of purity, with a view of later enlarging the scope of its activity as the conditions may warrant. Its favorable location, its close association with some of the largest tungsten ore producers, and its large and entirely modern equipment will place it in a position to meet any urgent demands upon its capacity. The company solicits correspondence with all manufacturers in the iron and steel branch, the main property of whose products consists in special hardness and resistance to abrasion, properties which can in no better way be secured than by the addition of tungsten to the raw material, no matter whether it be crucible steel, open-hearth steel, cast iron or any other form of iron or steel used in the industries.

Life Saving in Mines.—The Daily Consular Reports of Sept. 25 contain an illustrated description of an apparatus of Profs. Bamberger and Boeck, for the purpose of eliminating the dangers accruing from poisonous gases generated by explosions, etc. There are two types of apparatus, one for continual use while at work and another for use in the moment of danger. Provision is made for both generating the oxygen needed for breathing and for absorbing the carbon dioxide. This is accomplished by means of sodium-potassium peroxide. The use of "oxone," now made by the Roessler & Hasslacher Chemical Co., suggests itself. This is fused sodium peroxide. Oxone, put into water, generates oxygen, while the sodium hydrate formed on the decomposition of sodium peroxide, absorbs carbon dioxide. Dr. von Foregger's Electrochemical Society paper, printed on another page of this issue, should be referred to in this connection.

Microscopes.—We have received from the Bausch & Lomb Optical Co., of Rochester, N. Y., their catalogue A of microscopes and accessory apparatus. The issue of this catalogue marks the completion of the fiftieth year of the business of this firm and of the establishment of the optical industry in America. During this half century the company has developed from a small beginning until it now employs over 1200 workmen in the production of optical instruments, which the ever-increasing demand for their products in all parts of the world requires. The catalogue is not only an extremely well illustrated price list of the instruments made by this company, but gives much information for users of optical instruments. We have also received from the same company their smaller catalogue on projection and photomicrographic apparatus, botanical and entomological equipment and supplies for elementary school laboratories, new apparatus for use in plant physiology, and microscopical stains.

Tanks.—The W. E. Caldwell Co., of Louisville, Ky., have sent us their illustrated catalogue of tanks, towers and tubs, made of steel or of wood or of wood and iron combined. This company has been building tanks and towers for twenty-seven years, and also makes tanks for special purposes, including acid tanks, mining tanks, plating tanks, etc.

Filter Papers.—We have received from Messrs. Carl Schleicher & Schuell, of Dueren, Germany, their catalogue with some samples of filter papers (in sheets, rolls, circles and folded filters). They manufacture filter papers in the most various forms and sizes and in different degrees of thickness and hardness, so as to meet any requirements of industrial or laboratory practice. These different brands are fully described in the catalogue. Messrs. Eimer & Amend, of New York City, are the sole agents for the United States.

"Gold Galvanizing."—A recent pamphlet of the United States Electrogalvanizing Co., Brooklyn, N. Y., deals with the advantage of electrogalvanizing over the hot process, and describes four special new devices which have recently been patented by Mr. Potthoff, the patents being owned by the above-named company. The first device serves for galvanizing long material from 6 inches up to bar-iron or pipes 20 feet and longer; the latter can be coated inside and outside, or outside only, according to requirements; the same device can also be used for sheet metal. A second apparatus serves for galvanizing small articles of any description, as nails, screws, small bolts, stampings, castings, etc. A third device is designed for wire of all kinds, and a fourth one for irregular shaped material which can only be handled by hand—the old method, but greatly improved upon.

Charging Apparatus.—A well written and illustrated booklet, recently issued by the Wellman-Seaver-Morgan Co., of Cleveland, deals with charging and manipulating apparatus for iron and steel works equipments. There are two sections, the first relating to charging apparatus for open-hearth furnaces, the second to charging and manipulating apparatus for reheating furnaces.

Morse Chain Co.—When the members of the American Electrochemical Society meet next spring in Ithaca, they will be able to see the new plant of the Morse Chain Co. which is now being erected there, and is to be operated in conjunction with the present factory of the company at Trumansburg, N. Y. The main building of the new plant will contain the general offices and will be three stories in height; the first floor will be used for the machine shop, and a floor space of 64 x 236 feet has been set apart for this purpose. Separate one-story buildings will be provided for the foundry, the forge shop, the pattern shop and the power house.

Mechanical Stokers.—That the mechanical stoker has reached such a state of perfection as to be considered indispensable in the equipment of modern boiler plants is indicated by the large number of orders booked by the Westinghouse Machine Company for the Roney stoker, a type of their exclusive manufacture. During the past ten years this company has developed the Roney stoker by successive improvements until it has become capable of meeting successfully all the requirements of heavy modern service. During the past month orders have been received for no less than fifty-one Roney mechanical stokers, ranging in size from 54 x 20-inch grate to 132 x 26-inch grate, the largest of the orders being that of the Pennsylvania Railroad for six 132 x 26-inch grate stokers, and five 100 x 20-inch grate stokers.

Factory Welfare Work.—We have received from Messrs. Crosfield & Sons, Ltd., The Erasmic Co., Ltd., Warrington, England, an interesting illustrated pamphlet which bears the modest title, "Notes on Some Improvements at Bank Quay Soap and Chemical Works, 1900 to 1905." It deals with the social improvement of the condition of the working people by means of recreation clubs, bowling, cricket, swimming, dancing, music, etc. clubs, fire brigade, life insurance, youth's education, etc. Other paragraphs deal with cleanliness in the works, absence of smoke, medical aid, compulsory medical examination, etc. "Every person who has been in the continuous employ of the firm for fifteen months on April 1, is allowed a week's holiday with full pay during the summer months, the choice of date being left as much as possible to the individual." "The firm has tried profit-sharing schemes in a few departments, and the success has been sufficient to induce it to extend the principle as far as possible. The schemes are adapted to the varying conditions in the different departments, but the main principle is that quality as well as quantity of output shall be considered in estimating the profits. In different departments increments from 14 to 25 per cent on the weekly wages are earned." Messrs. Joseph Crosfield & Sons have recently been favored with the Royal Warrant as Manufacturers by special appointment to his Majesty the King of England.

Alkali in China.—The Daily Consular Report of Sept. 26 contains some notes which should interest our manufacturers. The entire business in China is now, since 1901, monopolized by Brunner, Mond & Co., of Northwich, England. The products sold are 98 per cent carbonate of soda; caustic soda in three grades, 97 to 98, 90 to 92, 76 to 78 per cent; bicarbonate

of soda, refined and mineral water; soda crystals; concentrated crystal soda; chloride of lime (sold at 5.50 Shanghai taels per 100-pound case; 1 tael = 52 to 58 cents); sulphate of ammonia. The business of the English company, starting from nothing, "has grown to large proportions. Their sales have reached 1500 tons of 2240 pounds a month of all products, and rarely fall below 500 tons of 2240 pounds a month, at an average price of approximately $50 a ton. In order successfully to compete with this firm it would be essential to build a warehouse on the water front at a cost of $20,000 in round numbers to carry the stock required for current business. * * * It would also be essential for a competing firm to possess a capital sufficient to withstand a cut in prices."

ORE BREAKERS.—The ALLIS-CHALMERS Co. has shipped to San Francisco a consignment stock of Gates rock and ore breakers of various styles and sizes, together with standard repair parts which may be required for Gates breakers which that company has already installed in various plants in California and neighboring States. It will interest the Western customers of the Allis-Chalmers Co., who have in use any of their Gates rock and ore breakers, to know that by this arrangement they will be able to secure prompt delivery of repair parts for their machines. This venture will also enable the Allis-Chalmers Co. to make immediate shipment of complete crushers required in that part of the country, or in the islands of the Pacific. The company's San Francisco offices are located in the Rialto Building.

DRY AIR FOR BLAST FURNACES.—In view of Mr. James Gayley's revolutionary work introducing the dry blast into the metallurgy of iron, a recent folder of the DE LA VERGNE MACHINE Co. is interesting. It illustrates the air-drying system of this company. The incoming undried air passes first through a fore-cooler, where it is partially cooled by water, and then through a regenerator to the first refrigerated chamber, where it is passed over coils of cold brine or direct expansion ammonia pipe, over which chloride of calcium solution is continually circulated, cooling it down to about 50° F. The cooled, moist air now passes through a series of screens, which separate out a large percentage of the moisture, after which it passess into the second refrigerating chamber, which has a temperature several degrees below that in the first chamber. Here the air is cooled to about 32° F., and then passes through a second spray catcher, and from there to the regenerator (in which the outgoing air is heated and the incoming air refrigerated). Then the air goes into the blowing tubs. Under certain conditions it may be advisable to leave out the regenerator, since the increased volume of the air heated in the regenerator decreases the efficiency of the blowing engines.

MODERN CIRCUIT-BREAKER PRACTICE.—Under this title the CUTTER ELECTRICAL & MFG. Co., of Philadelphia, has recently issued a profusely illustrated book describing, besides some of their established standards, a number of more recently developed types. The circuit breakers of this company are well known under the name of I. T. E., which stands for Inverse Time Element (the greater the need for the operation of the instrument the shorter the time within which it responds). Of the many types of circuit breakers which have been devised to meet almost all possible requirements, some of special interest for electrochemical and electrometallurgical works and for storage battery plants, are those which prevent the voltage dropping below a certain value and those which prevent a reversal of the current. To meet special requirements—such as are liable to arise in electrolytic refineries, etc.—circuit breakers of very large capacity are now available. Thus, the present book shows the illustration of 10,000-amp., 250-volt double-pole circuit breaker; it is 30 inches high, 24 inches wide and has a maximum depth when open of 20 inches from the switchboard to the most extended portions of the operating handle.

ORE REDUCTION MACHINERY.—Several new types of ore reduction machinery have been devised in recent years by Mr. William A. Merralls, of San Francisco, and are now placed on the market by the MERRALLS MACHINERY Co., 1123 Broadway, New York City, and the MERRALLS ENGINEERING Co., 106 Shuter Street, Toronto, Can. Perhaps the most interesting of these new machines is the Merralls' improved stamp mill, which has the following novel features. Each stamp has its own separate mortar box, by reason of diaphragms cast in the solid mortar-box frame, and is, therefore, not burdened or interfered with in its work by the other stamps as in the open battery. Each stamp has its own ore feeder and its own water supply, and has screens on all four sides, so that the moment the material is crushed fine enough to pass the screens it goes onward, thus preventing sliming, making room for incoming ore and greatly increasing the production. The mill being practically free from the swash of the open mortar, which causes so much flowing and cutting of mercury, has great amalgamating capacity. Each stamp can be hung up for cleaning up or repairs while the balance of the battery go on crushing their full quota. The mortar permits of much heavier stamps being used, with a corresponding increase of capacity. For hard ore 1200-pound stamps are recommended. It is stated that on account of these improvements each stamp in a battery is enabled to handle from 6 to 8 tons per 24-hour day of hard quartz through a 40-mesh screen, wet, at an expenditure of about 2 hp. per 1200-pound stamp. With the four-side discharge, outside of each screen a battery plate is inserted, and it is stated that these battery plates secure from 60 to 90 per cent of the free gold right in the battery. Mr. Merralls has also constructed a new ore breaker and an improved Chili mill, and advocates the combined use of all three machines; the ore breaker for preparatory crushing, the stamp mill for further reduction to 8 or 101mesh, and the Chili mill for fine grinding.

Personal.

Mr. WALTER H. WHITESIDE, recently elected president of the Allis-Chalmers Co., joined the organization in July, 1904, when he accepted the position of general manager of sales. He came at the time when the company, which had just taken over the Bullock Electric Manufacturing Co., needed the injection of a vigorous and energetic personality into its sales force. It was not merely that he had to become familiar with all the intricacies of the company's widely varied products, but the new interests and the old had to be consolidated, the sales organization enlarged and its efficiency increased. His promotion to the presidency indicates with what success Mr. Whiteside has met in his efforts. In taking up this higher and more responsible position, Mr. Whiteside has behind him not only the confidence of his organization but a long and varied business experience, in which he has filled many executive positions. His achievements have won him recognition as a man of marked administrative ability. Mr. Whiteside is a member of the American Institute of Electrical Engineers, of the Engineers' and Lawyers' Clubs, of New York, of the Mid-Day Club, Chicago, and of the Milwaukee Club.

WALTER H. WHITESIDE.

Dr. Paul Heroult, the distinguished French metallurgist, has returned to this country. On his present visit he is accompanied not only by Mrs. Héroult but by three of his children, since he intends to stay here for about a year to look after his interests in the development of electric furnace methods in the metallurgy of iron and steel in this country and Canada. Dr. Héroult recently expressed the conviction that not too far in the future the largest steel-making furnace will be an electric one.

Mr. W. S. Doran has just been appointed manager of the power department of Allis-Chalmers Co. In this capacity he will have complete charge of the company's commercial affairs pertaining to reciprocating steam engines, steam and hydraulic turbines, condensers, gas engines, blowing engines for iron and steel blast furnace service, and rolling mill engines, with headquarters at the general offices of Allis-Chalmers Co., Milwaukee, Wis. Mr. Doran was formerly associated with the British Westinghouse Electric & Mfg. Co., Ltd. As an evidence of the high esteem with which Mr. Doran is regarded by his business associates a banquet was tendered him on the eve of his departure from England, attended by many well-known railway officials, manufacturers, electrical engineers and representatives from practically all the large electrical manufacturing concerns in England.

The General Storage Battery Co., of New York City, have secured the services of Mr. J. B. Cowen, formerly prominently connected with the G. I. Co. for many years past, for the management of their sales department.

Mr. Eugene Holcomb has recently been appointed manager of the newly created foreign department of the Allis-Chalmers Co., to take charge of all the foreign agencies and foreign selling representatives of the company. Not only will he supervise the work of the well-established European and South African offices and all Eastern Hemisphere agencies, but he will also have direct control over the South and Central American business for the company. With the engineering possibilities and projects in South America Mr. Holcomb is thoroughly familiar, having spent a number of years in that country. The past three years he has had immediate charge of the Westinghouse companies' interests in Argentina. Mr. Holcomb's headquarters will be at the general offices of the company at Milwaukee, Wis.

Mr. W. S. Landis, of the department of metallurgy of Lehigh University, has sailed for Europe to spend a semester in Heidelberg, where he will study mineralogy with Prof. Goldschmidt. Mr. Landis' many friends will wish him bon voyage and a happy return. At the recent Bethlehem meeting of the American Electrochemical Society Mr. Landis, as secretary of the local committee, did very effective work in making the visitors feel at home and in doing everything in his power to make the meeting successful.

Digest of U. S. Patents.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

Electric Smelting and Reduction Processes.

(Continued.)

No. 651,718, June 12, 1900, Henri Leleux, Paris, France.

Employs a metal, specifically iron, as an agent to reduce argentiferous galena and ores containing copper or nickel in combination with sulphur, arsenic or antimony. The iron withdraws the metalloids from the lead, silver, copper and nickel. Some arsenic, arsenic sulfide, iron arsenide, etc., are volatilized and pass off. The reduced metals collect beneath a floating layer of iron sulfide or arsenide, and are tapped into a mold. The reaction being exothermic, electric energy is only required to fuse the ore. The furnace shown comprises a vertical chamber of bauxite bricks, with feed-hoppers and gas outlets at its upper end. A massive iron electrode, to effect reduction, depends into the chamber. The hearth constitutes the other electrode and preferably consists of the metal or alloy to be produced, although carbon may be employed in recovering lead, silver or copper. In smelting nickel, the hearth preferably consists of a nickel slab, having a water-cooled terminal of cast steel.

No. 658,412, Sept. 25, 1900, Gustaf M. Westman, New York.

Ores of arsenic, as, for instance, mispickel, are reduced in an electric furnace designed particularly for the recovery of metallic arsenic and of such precious metals as may be present. The ore is charged onto a flat hearth, at opposite ends of which are depressions containing water-cooled electrodes of copper. On the passage of the current the ore is melted, and the metallic arsenic distilled into a condenser. Alternating currents are preferable, on account of the convenient control and freedom from electrolytic effects. When the ore contains precious metals a collecting layer of lead is maintained within the depressions above each of the electrodes, a single charge of lead being stated to serve for several charges of arsenical ore.

No. 659,926, Oct. 16, 1900, Charles B. Jacobs, East Orange, N. J.

An abrasive material is produced by heating bauxite or other aluminium hydrate to quiet fusion in an electric furnace, and permitting the melt to cool slowly. The walls of the furnace comprise a sheet-iron casing lined with firebrick or ground lime and interiorly faced with carbon bricks. The hearth is similarly constructed, and is arranged to be slowly lowered during the operation. A plurality of pairs of horizontal opposed electrodes enter the furnace above the hearth at its highest position, and the charge is fed upon these electrodes, the melted product collecting on the hearth. Preferably the bauxite is primarily calcined. The product is crystalline, somewhat harder than corundum, and possesses a much greater degree of toughness. The crystalline character, and hence the toughness of the product, is governed by the rate of cooling or by subjecting the mass to agitation during cooling.

No. 662,548, Nov. 27, 1900, Bernhard Scheid, Frankfort-on-the-Main, Germany.

Produces silicon containing 99 per cent Si and traces of carbon, iron and aluminium, but substantially free from carbide of silicon, by reducing quartz by carbon in the presence of acid, neutral or basic silicates of the alkali or alkali earth metals. The preferred charge consists of quartz and carbon in combining proportions, together with water glass of the composition $Na_2Si_2O_5$, the latter being added in the proportion of 5 to 30 per cent of the quartz. The current may be either alternating or direct. It is stated that the efficiency of the process is about 30 per cent. It is supposed that the melted silicate serves to instantly condense the vapors of silicon, thereby preventing the formation of silicon carbide.

No. 673,761, May 7, 1901, and No. 676,577, June 18, 1901, Alfred H. Cowles, Cleveland, Ohio.

Reduces sodium aluminate by coke or a hydrocarbon, recovering metallic sodium. The aluminate is mixed with crushed coke, or saturated with pitch, etc., the reducing agent being present in substantially equivalent proportions, and is reduced in an electric furnace provided with walls and hearth which are permeable to the sodium vapor. For this purpose they are constructed of compacted but porous carbon, or of hard carbon containing blocks or masses of porous carbon, the furnace being surrounded by a water-cooled spaced jacket, forming a condenser for the liquid sodium. By adding a volatile metal, as zinc, to the charge, the condensed product will be an alloy of sodium with this metal. Iron, copper or tin may be added to the charge, in which case the reduced product remaining within the furnace is the corresponding aluminium alloy. The furnace is arranged to be worked under considerable gas pressure, whereby the transfer of the sodium through the porous walls is aided. Describes also the reduction of mixed sodium and calcium compounds, in which case sodium is recovered in the condenser and calcium carbide produced in the furnace.